ANTENNA PATTERN STUDY

TASK II

CONTRACT NUMBER: UI/ARI-88-1

FINAL REPORT

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PREFACE

The work described in this report was performed in compliance with the requirements of Contract UI/ARI-88-1, Antenna Pattern Study, Task II. Two electromagnetic scattering codes, NEC-BSC, Revision 2, and ESP4 were installed on a Compaq 386/20 computer, together with graphic display codes and auxiliary input data codes. The NEC-BSC and ESP4 codes were developed at the Electroscience Laboratory of Ohio State University. Several revisions were made on these codes by ARI to make them suitable for use on the Compaq computer.

The writer wishes to acknowledge the very valuable assistance of Mr. Mike Vinson of ARI in the revision and compilation of the software described in this report.
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1.0 INTRODUCTION

Two electromagnetic scattering codes, NEC-BSC and ESP3, have been delivered under a previous contract (UI/ARI-87-3) and have been installed on a NASA VAX computer for use by George C. Marshall Space Flight Center antenna design personnel. The purpose of the work performed under this contract was to update the existing codes and certain supplementary software, to install the codes on a computer that will be delivered to the customer, to provide capability for graphic display of the data to be computed by use of the codes and to assist the customer in the solution of specific problems that demonstrate the use of the codes. With the exception of one code revision, all of these tasks have been performed.
2.0 CODE REVISIONS

Tasks 1 through 3 of the Statement of Work of this contract call for acquisition and evaluation of the scattering code NEC-BSC, Revision 3. This revision was expected to be released by Ohio State University shortly after award of this contract. However, it has not yet been released, and recent communications with OSU indicate that it will not be released for several more months. Therefore, it was not possible to incorporate the revised code in this effort. Discussions between all concerned parties have led to an agreement that installation of the existing version of the code on the PC will be satisfactory.

No revision of the moment-method code ESP3 was required under the contract, inasmuch as the code was not expected to be revised. However, use of the code by ARI and by others revealed an that an error existed which degraded the quality of the computed data under certain conditions. The error was subsequently corrected by OSU and a revised version ESP4 was released. That version was immediately procured and was installed on the Compaq 386/20 computer.

Several revisions in the two codes were made by ARI and will be discussed in detail.
3.0 INSTALLATION OF NEC-BSC AND ESP4 ON 386/20 COMPUTER

The random-access memory requirement for NEC-BSC does not exceed that which can be accommodated by the 16-bit Microsoft compiler. The requirement is also essentially independent of the electrical size (size measured in wavelengths) of the scattering body or bodies for which the data are being computed. It depends only on the number of scattering elements being modeled, the dependency being somewhat linear. It is capable, in its present form, of solving scattering problems involving fairly complex structures, and is considered adequate for typical NASA uses in that respect.

The ESP4 code, like its ESP3 predecessor, has a very different type of memory requirement. The required amount of RAM depends on the electrical size of the scattering body. The moment method, on which the code is based, involves the formation and inversion of a square matrix, the size of which depends on the number of "patches" into which the scatterer surface is divided. The amount of memory required to perform the required computations increases exponentially with model size. An assessment of memory requirement for the 386 computer, taking into account the type of scattering problems that may be expected to be encountered by MSFC design personnel, as well as run time and cost, was made by ARI. A compromise was made between these factors and the computer RAM was increased to a value of 9 megabytes. This compromise value is considered adequate to accommodate all typical design problems concerning antenna
radiating elements and associated electrically conductive surfaces. It can be used for scattering bodies which are roughly three or four wavelengths (or less) across.

The large amount of memory required by the ESP4 code cannot be accessed by a 16-bit compiler, so that a 32-bit compiler had to be acquired. It was also decided that both codes should be compiled by use of the same compiler. The initial choice was the Lahey compiler. This compiler was procured and used to compile the NEC-BSC code, which was then tested on examples for which the correct output data were known. Initial attempts to do the compilation were unsuccessful, and it was discovered that the compiler would not accept certain statements as formatted in the source code. The format of these statements was changed and the compilation was accomplished. However, use of the executable code on test cases did not produce correct data. Further investigation revealed that certain statements in the source code, although expressed in good Fortran, could not be properly compiled. The vendor was apprised of this deficiency and very promptly made a correction to his software. A revised version of the compiler was then made available. This version correctly compiled the statements mentioned above, and the resulting executable code produced correct data when flat-plate scatterer models were used. However, when cylindrical scattering models were introduced, incorrect data were again generated.

The errors produced in the executable code were suspected to
be related to some optimization feature in the Lahey compiler. The source code, as received from OSU, would produce incorrect output data when compiled on the VAX in the OPTIMIZE mode. If compiled in the NOOPTIMIZE mode, the resulting executable code would produce good data. Ohio State personnel experienced the same results. It was found by ARI that the source code could be correctly compiled on the VAX in the OPTIMIZE mode if a section of the main program was removed and made into a subroutine which is called at the appropriate point by the main program. This change was made, and remains in the code as delivered. However, compilation on the Compaq PC, using the Lahey compiler, still did not produce a good executable code.

At this point, it was decided that it would not be wise to continue the effort to use the Lahey compiler, and that an alternate choice should be considered. Acting on that decision, the SVS FORTRAN-386 compiler was procured from Science International Corporation, Los Altos, California.

Initial efforts to compile the NEC-BSC source code with the SVS compiler were not successful. Again, errors occurred that seemed to be associated with optimization. An inquiry was made to the vendor and it was learned that the compiler contains five optional levels of optimization: 0 through 4. The default level is level 4 (the highest), and is the level that was being used. A change to level 3 was made and successful compilation was accomplished. After being compiled and linked, the resulting
executable code was tested and found to generate valid data on all test cases on which it was tried.

After successful compilation and linking of NEC-BSC, the ESP4 source code was also successfully compiled and linked, using the SVS COMPILER and the Phar Lap linker. It also was found to produce valid output data on known test cases.
4.0 GRAPHICS CAPABILITY

A requirement exists for providing a graphic display of the data generated by the NEC-BSC and ESP4 codes. These codes produce output files which contain data relating to various components of the computed field, and for optional pattern planes. Thus, the desired graphics code should provide access to any polarization component that the user wishes to view and should do in convenient manner. It should also perform scaling functions which will make most effective use of the plotting area and will select the most appropriate increments of angle and amplitude for the data being displayed. The two graphic codes that are provided meet these requirements.

The first of the two codes, written for use with NEC-BSC, is called PLTGTG. The second, for use with ESP4, is PLTMM. These codes make use of a set of graphics routines called GRAFMATICS. Both codes request from the user the desired polarization component, which he then enters from the keyboard. The code then selects the appropriate columns of data from the output file, determines whether the pattern cut is of the great-circle or the conical type (for NEC-BSC), performs the scaling, sets up the grids and displays the data. The resulting plot can then be viewed and, if desired, transferred to the printer for hard copy. Examples are shown in Figure 1.
Figure 1. Example of antenna pattern display.
5.0 USE OF THE SCATTERING CODES

The NEC-BSC and ESP4 codes are stored on the hard disk in two subdirectories. NEC-BSC is stored in subdirectory GTD. ESP4 is stored in subdirectory MOMENT. They are conveniently executed and displayed by use of two batch files, GTD (in the GTD subdirectory) and MM (in the MOMENT subdirectory).

To run the NEC-BSC code, the GTD subdirectory is selected, after which the operator simply types the command GTD on the keyboard. This command sets up a sequence of actions. The first of these actions is to install the GRAPHICS capability. The second is to delete any previous plot file. The NEC-BSC executable code is then called and executed. In the course of execution, it will ask the user the name of the input data file to be used in the computation. This file must have already been prepared. The output data are then computed and placed in the output files. Figure 2 shows the messages that are output to the monitor as the code is being executed. One of the output files, OUTPUT.DAT, contains the complete output information, including input data and other descriptive information. It may be output to the printer at any time. The other file, PLOT.DAT, contains only numeric data to be accessed by the graphics code PLTGTGTD. This code is then called and requests that the user identify the polarization component that he wishes to display. After that piece of information has been entered from the keyboard, the graphics code selects and displays the requested data.
What is the name of the input file?
EXAMPLE1.DAT
ReCE: FAR ZONE PLATE TEST, EXAMPLE 1A.
ReUN: UNITS IN INCHES
ReFR: FREQUENCY IN GHZ.
RePD: PATTERN CUT
RePG: PLATE GEOMETRY
ReSG: SOURCE GEOMETRY
ReXQ: EXECUTE CODE
ReEN: END CODE

ENTER POLARIZATION COMPONENT DESIRED:
1 - E-THETA
2 - E-PHI
3 - MAJOR AXIS OF POLARIZATION ELLIPSE
4 - MINOR AXIS OF POLARIZATION ELLIPSE
5 - TOTAL AMPLITUDE

Figure 2. Monitor display for execution of NEC-BSC.
Execution of ESP4 is accomplished in essentially the same way. In this case, the user inputs the command MM from the keyboard, rather than GTD. The requests for input file name and polarization component appear as before, and the display is immediately presented on the monitor. The degree of completion is shown on the monitor screen as the impedance matrix is computed and subsequently, as the pattern is computed. An example of this display is shown in Figure 3.

Certain changes were made by ARI in the NEC-BSC code to include the E-theta and E-phi components, together with the major and minor axes of the polarization ellipse and the total field, all in a single plot file. This change permits the plot code PLTGTD to access any selected component from the one file.
C:\MOMENT>MM
C:\MOMENT>GRAPHICS
C:\MOMENT>DEL PLOT.DAT
C:\MOMENT>ESP4
$Enter filename for input
EXAMPLE1.DAT
Opening EXAMPLE1.DAT
Beginning Z matrix computation
[2] MATRIX COL. 1 OF 15 FINISHED
[2] MATRIX COL. 2 OF 15 FINISHED
[2] MATRIX COL. 3 OF 15 FINISHED
[2] MATRIX COL. 4 OF 15 FINISHED
[2] MATRIX COL. 5 OF 15 FINISHED
[2] MATRIX COL. 6 OF 15 FINISHED
[2] MATRIX COL. 7 OF 15 FINISHED
[2] MATRIX COL. 8 OF 15 FINISHED
[2] MATRIX COL. 9 OF 15 FINISHED
[2] MATRIX COL. 10 OF 15 FINISHED
[2] MATRIX COL. 11 OF 15 FINISHED
[2] MATRIX COL. 12 OF 15 FINISHED
[2] MATRIX COL. 13 OF 15 FINISHED
[2] MATRIX COL. 14 OF 15 FINISHED
[2] MATRIX COL. 15 OF 15 FINISHED
Computing radiation pattern
Theta = 0.0
Theta = 3.0
Theta = 6.0
Theta = 9.0
Theta = 12.0
Theta = 15.0
Theta = 18.0
Theta = 21.0
Theta = 24.0
Theta = 27.0
Theta = 30.0
Theta = 33.0
Theta = 348.0
Theta = 351.0
Theta = 354.0
Theta = 357.0
Theta = 360.0

CPU RUN TIME FOR RUN 1 GEOMETRY 1 = 70.25 SECONDS

TOTAL CPU RUN TIME = 70.53 SECONDS

Programmed STOP
C:\MOMENT>PLTMN
THE PATTERN IS READY TO BE PLOTTED

ENTER POLARIZATION COMPONENT DESIRED:
1 - E-THETA
2 - E-PHI

Figure 3. Monitor Display for ESP4.
6.0 SPECIFIC STUDIES

6.1 SCATTERING STUDY FOR SHUTTLE EXTERNAL TANK

During the course of this contract, MSFC antenna design engineers expressed a concern with the type of scattering that will occur from the external fuel tank of the Shuttle when radar transponder antennas are located on the forward skirts of the solid-rocket boosters (SRB). The NEC-BSC code was viewed as a useful tool in predicting the composite radiation pattern that would result from the combination of direct radiation and the radiation that would be scattered by the external tank. However, a question existed regarding the validity of the data that would be derived by use of the code. The external tank would be modeled as a smooth, perfectly-conducting right circular cylinder. That model does not exactly agree with the actual shape of that part of the tank that lies alongside the antenna location. The surface of the tank in that region (the inter-tank section) does not have a smooth cylindrical surface. Additional strength is provided in the intertank structure by the use of external longitudinal stringers. These stringers produce a somewhat corrugated shape at the scattering surface of the tank.

A study was performed by ARI to assess the validity of the data that would be derived by use of the NEC-BSC code, treating the intertank skin as a smooth cylindrical surface. The work performed in that study and the conclusions that were drawn are described in Report ARI/R-89-573, ELECTROMAGNETIC SCATTERING BY SHUTTLE EXTERNAL TANK SURFACE, dated February 27, 1989.
6.2 OBSCURATION COMPUTATION FOR SRB RADAR ANTENNAS

An intermediate step in determining the adequacy of the radar transponder antenna patterns for two specified radar stations was computation of the optical shadow produced by the various bodies comprising the shuttle cluster in the launch configuration for a source located at an antenna location. This computation was performed by ARI, using the computer code SHADOW. In the absence of scale-model antenna pattern measurements, the results of the computation were used by NASA in preliminary assessment of the adequacy of the antenna arrangement and the radar station layout. A detailed description of the obscuration computation is given in report ARI/R-89-575, TRANSMISSION PATH OBSCURATION FOR RADAR TRANSPONDER ANTENNAS ON SHUTTLE SRB, dated March 24, 1989.
7.0 CONCLUSIONS

The two scattering codes NEC-BSC and ESP4 have been installed on a COMPAQ DESKPRO 386/20 computer, together with graphics software and auxiliary input data codes. All required revisions have been made and the codes are ready for use. It is believed that the codes, in their present form, will provide a valuable predictive capability for antenna patterns associated with large and complex scattering bodies with which NASA is concerned. The absence of the expected second revision of NEC-BSC code is regrettable, but the current revision, installed on the Compaq computer, with graphic display, is expected to be highly useful. It is recommended that the third revision be acquired and installed on the computer when it becomes available.
APPENDIX A

INPUT DATA CODES
PROGRAM BSCINPUT

THIS PROGRAM PROVIDES AN INTERACTIVE MEANS FOR ENTERING INPUT DATA INTO THE OHIO STATE UNIVERSITY NEC-BSC PROGRAM. THE REQUESTED PARAMETER VALUES ARE WRITTEN TO A DATA FILE TO BE CALLED BY PROGRAM "SCAT".

THIS PROGRAM WAS WRITTEN BY:

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Revision date written by Mike Vinson

Revision date: January 27, 1989

Character*3 STRING
Character*36 Temp
Character*36 INPUT
Character*2 NZERO
Character*1 Answer
Character*30 Description(33)
Character*40 Line
Character*40 Section(10)

Description(1) = 'BP: Back or Bistatic Scatter'
Description(2) = 'CE: Last or only Comment'
Description(3) = 'CG: Cylinder Geometry'
Description(4) = 'CM: Comment Card'
Description(5) = 'EN: End program'
Description(6) = 'FM: Swept Frequencies'
Description(7) = 'FR: Frequency'
Description(8) = 'GP: Infinite Ground Plane'
Description(9) = 'LP: Line Printer Output'
Description(10) = 'NC: Next set of Cylinders'
Description(11) = 'NG: No Ground Plane'
Description(12) = 'NP: Next Set of Plates'
Description(13) = 'NR: Next Set of Receivers'
Description(14) = 'NS: Next Set of Sources'
Description(15) = 'NX: Next Problem'
Description(16) = 'PD: Far Zone Pattern Cut'
Description(17) = 'PG: Plate Geometry'
Description(18) = 'PN: Near Zone Pattern Cut'
Description(19) = 'PP: Plotter output'
Description(20) = 'PR: Gain or Coupling Factors'
Description(21) = 'RA: Receiver Array Geometry'
Description(22) = 'RD: Far Zone Range'
Description(23) = 'RG: Receiver Geometry'
Description(24) = 'RM: NEC-MM Receiver Input'
Description(25) = 'RT: Rotate-Translate Geometry'
Description(26) = 'SA: Source Array Geometry'
Description(27) = 'SG: Source Geometry'
Description(28) = 'SM: NEC-MM Source Input'
Description(29) = 'TO: Test Options'
Description(30) = 'UF: Model Scale Factor'
Description(31) = 'UN: Units of Geometry'
Description(32) = 'US: Units of Source Size'
Description(33) = 'XQ: Execute Code'
Write(*,300)
300 Format(1H$, 'Would you like to edit the existing file? ')
   Read(*,310) Answer
310 Format(A1)
320 Format(A40)

See if the user wants to edit the current file
If( Answer .eq. 'Y' .or. Answer .eq. 'y') then
   Enter the change section
   Open( Unit = 1, File = 'Input.bak', Status = 'Old')
   Open( Unit = 2, File = 'Input.dat', Status = 'Unknown')
   Read(1,320,End=999) Line
   Call Search(Line,Description,k)
   Section(1) = Line
   n = 0
   icount = 1
   Do While (n .eq. 0)
      Continue
      Read(1,320,End=999) Line
      Call Search(Line,Description,n)
      icount = icount + 1
      Section(icount) = Line
      If( n .eq. 0) goto 405
   End do
   icount = icount - 1
   Call Change(Section,k,Description,icount)
   goto 400
999 Continue
   Call Change(Section,k,Description,icount)
   Close(2)
Else
   OPEN(1,FILE='FOR005.DAT',STATUS='NEW')
C
STRING = 'CE:'
WRITE(*,1)
   1 FORMAT(1H$, 'Enter Comment (max 36 chars.) ')
   READ(*,2) INPUT
   WRITE(1,3)STRING, INPUT
   3 FORMAT(A3,A36)

Get units for this run from the user.
1000 WRITE(*,200)
   200 FORMAT(1X,'Enter number indicating units to be used -'/15X,
       '1 = Meters'/15X,'2 = Feet'/15X,'3 = Inches'/)
   READ(*,2) INPUT
If( Input .gt. '3' .or. Input .lt. '1' ) Then
   Write(*,*) 'Your selection was out of range. Please try again'
   goto 1000
End if
C
STRING='UN:
WRITE(1,9) STRING
WRITE(1,2) INPUT
C
Get frequency from user.
WRITE(*,5)
5 FORMAT(1X,'FREQUENCY IN GHZ.?')
READ(*,2) INPUT
STRING='FR:
WRITE(1,9) STRING
WRITE(1,2) INPUT
7 FORMAT(I2)
8 FORMAT(I1,1X,A1)
9 FORMAT(A3)
C
WRITE(*,10)  *** Orientation of Pattern Axes ***' /
STRING='PD:
WRITE(*,15)
15 FORMAT(1X,'THETA, PHI FOR Z AXIS, THETA, PHI FOR X AXIS (1 LINE)
READ(*,2) INPUT
WRITE(1,9) STRING
WRITE(1,2) INPUT
C
*** TYPE OF PATTERN CUT ***
C
WRITE(*,210)
210 FORMAT(1X,'TYPE OF PATTERN CUT DESIRED (GREAT CIRCLE OR CONICAL)' '1/' T = CONICAL CUT (CONSTANT THETA)'' F = GREE
2 CIRCLE CUT (CONSTANT PHl)''/ ENTER T OR F, FOLLOWED BY VALUE O:
3 THE FIXED ANGLE, ON ONE LINE.')
READ(*,2) INPUT
WRITE(1,2) INPUT
C
*** ANGULAR RANGE DESIRED ***
C
WRITE(*,220)
220 FORMAT(1X,'ANGULAR RANGE DESIRED FOR PATTERN: INITIAL ANGLE, FIN:
1 ANGLE, ANGULAR INCREMENT')
READ(*,2) INPUT
WRITE(1,2) INPUT
C
*** PLATE GEOMETRY ***
C
WRITE(*,40)
40 FORMAT(1X,'HOW MANY PLATES?')
READ(*,*) NOPLT
IF(NOPLT.LT.1) GOTO 82
C
STRING='PG:
DO 80 MP=1,NOPLT
WRITE(1,9) STRING
  80
C WRITE(*,50) MP
50 FORMAT(1X,'PLATE NUMBER ',I2,/ ' HOW MANY CORNERS?')
READ(*,7) NUM
NZERO='O'
WRITE(1,8) NUM,NZERO
C DO 70 ME=1,NUM
WRITE(*,60) ME
60 FORMAT(1X,'X,Y,Z POSITION OF CORNER NUMBER ',I2)
READ(*,2) INPUT
WRITE(1,2) INPUT
70 CONTINUE
80 CONTINUE
C

*** CYLINDER GEOMETRY ***

C 82 WRITE(*,84)
84 FORMAT(1X,'HOW MANY CYLINDERS?')
READ(*,*) NCYL
IF(NCYL.LT.1) GOTO 99
DO 94 N=1,NCYL
STRING='CG:'
WRITE(1,9) STRING
WRITE(*,86) N
96 FORMAT(1X,'LOCATION (X,Y,Z) OF ORIGIN, CYLINDER NO. ',I1)
READ(*,2) INPUT
WRITE(1,2) INPUT
C WRITE(*,88) N
88 FORMAT(1X,'CYLINDER NO. ',I1, ' ORIENTATION'/1X,'THETA-Z, PHI-Z, '
1ETA-X, PHI-X')
READ(*,2) INPUT
WRITE(1,2) INPUT
C WRITE(*,90)
90 FORMAT(1X,'CYLINDER RADII: RX, RY')
READ(*,2) INPUT
WRITE(1,2) INPUT
C WRITE(*,92)
92 FORMAT(1X,'POSITIONS & ANGLES OF END CAPS'/1X,'POSITION & ANGLE '
1R NEGATIVE END, POSITION & ANGLE FOR POSITIVE END.')
READ(*,2) INPUT
WRITE(1,2) INPUT
94 CONTINUE
C

*** SOURCE GEOMETRY ***

C 99 WRITE(*,100)
100 FORMAT(1X,' *** SOURCE GEOMETRY ***')
WRITE(*,110)
110 FORMAT(1X,'HOW MANY SOURCE ELEMENTS?')
READ(*,*) NWIRES
STRING='SG:'
DO 180 MS=1,NWIRES
WRITE(1,9) STRING
WRITE(*,120) MS
120 FORMAT(1X,'SOURCE ELEMENT NUMBER',I2/) WRITE(*,130)
130 FORMAT(1X,'X,Y,Z POSITION OF ELEMENT CENTER?') READ(*,2) INPUT
WRITE(1,2) INPUT
C
WRITE(*,140)
140 FORMAT(1X,'THETA & PHI ANGLES FOR LENGTH & WIDTH VECTORS/')
1(THETA-L, PHI-L, THETA-W, PHI-W') READ(*,2) INPUT
WRITE(1,2) INPUT
C
WRITE(*,160) MS
160 FORMAT(1X,'TYPE, LENGTH AND WIDTH OF ELEMENT',I2/) TYPE:
1 UNIFORM CURRENT DISTRIBUTION/-2 PIECEWISE SINUSOIDAL DISTRIBUTION/
READ(*,2) INPUT
WRITE(1,2) INPUT
C
WRITE(*,170)
170 FORMAT(1X,'EXCITATION (MAGNITUDE, PHASE) FOR ELEMENT',I2)
READ(*,2) INPUT
WRITE(1,2) INPUT
180 CONTINUE
STRING='XQ:' WRITE(1,9) STRING
STRING='EN:' WRITE(1,9) STRING
End if CLOSE (1)
END

Subroutine Search(String,Array,n)
Character*80 String Character*30 Array(33)
Search for the first two letters of the string in the first two letters of the elements of the array.

Do 10 i = 1,33
   If( string(1:2) .eq. Array(i)(1:2) ) then
      n = i Return
   End if
10 Continue
n = 0 Return
End
Subroutine Change(Section, k, Description, icount)

Character*40 Section(10)
Character*40 Line
Character*30 Description(33)
Character*1 Answer

Integer*4 k
Integer*4 icount
Integer*4 Offset
Integer*4 joffset

Character*1 Btemp(2)
Integer*2 Itemp

Equivalence ( Itemp, Btemp(1) )

Write(*,*)
Write(*,*)
Write(*,*) 'Command card found: ',Description(k)(1:3)
Write(*,*) 'This is described as: ',Description(k)(4:30)
Write(*,*) 'These are the cards in this set:'
Do 10 i = 1,icount
   Write(*,*) Section(i)
10 Continue
Write(*,*)
Write(*,90)

Format(1H$,'Do you want to change any of the cards in this SET?
Read(*,110) Answer
Write(*,*)
Write(*,*)

If( Answer .eq. 'Y' .or. Answer .eq. 'y') Then
   Do 20 i = 1,icount
500 Write(*,*) Section(i)
      Write(*,80)
80 Format(/1X,'Note: To insert a new card',/
      , before this card, just',/
      , type INSERT To delete',/
      , a card, type DELETE.' )
      Write(*,100)
   End if
100 Format(1H$,'Do you want to Change this card? ')
Read(*,120) Line
Answer = Line(1:1)

To test all possible combinations of the word insert in both upper and lower case, convert each of the first six letters to upper case.

Do 500 k = 1,6
   Btemp(1) = Line(k:k)
   if( itemp .ge. 97 .and. itemp .le. 122 ) then
      Itemp = Itemp - 32
      Line(k:k) = Btemp(1)
   End if
500 Continue
If (Line(1:6) .eq. 'INSERT') then
    Call Insert
    Goto 300
  End if
if (Line(1:6) .eq. 'DELETE') Goto 20
If (Answer .eq. 'Y' .or. Answer .eq. 'y') Then
    Write(*,*)
    Write(*,70)
    Format(//1X,'Note: Type ^ to begin and end inserted data:',/)
    Write(*,*) 'for this card. Type # to delete',/
    Write(*,*) characters.'/)
    Write(*,**) 'Enter the New card below (Space = no change):'
    Write(*,**) Section(i)
    Read(*,120) Line
    Ins_flag = 0
    Offset = 0
    Do 200 j = 1,40
        If (Line(j:j) .eq. '^') then
            Ins_flag = 1 - Ins_flag
            Offset = Offset + 1
            Goto 200
        End if
        If (Line(j:j) .eq. '#') then
            Do 125 m = j-Offset,39
                Section(i)(m:m) = section(i)(m+1:m+1)
            Continue
            Offset = Offset + 1
            Goto 200
        End if
        If (Line(j:j) .ne. '' .and. Ins_flag .eq. 0) then
            joffset = j - Offset
            Section(i)(joffset:joffset) = line(j:j)
        Else if (Ins_flag .eq. 1) then
            Do 130 m = 39,j-Offset,-1
                Section(i)(m+1:m+1) = Section(i)(m:m)
            Continue
            joffset = j - Offset
            Section(i)(joffset:joffset) = line(j:j)
        End if
    End if
    Continue
    End if
    Write(*,**)
    write(2,120) Section(i)
    Continue
Else
    Do 30 i = 1,i1count
        write(2,120) Section(i)
    Continue
End if
110 Format(A1)
120 Format(A40)
Return
End
Subroutine Insert

Character*40 Line
Character*1 Answer

1    Write(*,10)
10   Format('Type the card to be inserted:')
     Read(*,100) Line
     Write(*,200) Line
     Write(*,300)
     Read(*,90) Answer
     If( Answer .eq. 'Y' .or. answer .eq. 'y') then
         write(2,100) Line
     Else
         Goto 1
     End if
90   Format(A1)
100  Format(A40)
200  Format('Is this card correct?')
300  Return
End
PROGRAM INDAT4

This program provides an interactive means for entering input data into the Ohio state university esp4 program. The requested parameter values are written to a data file, specified by the user, in the proper order to be called by esp4.

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DIMENSION NCNRS(10)
DIMENSION X(10), Y(10), Z(10)
DIMENSION NPLA(10), BDSK(10), VGA(10), ZLDA(10)
DIMENSION PCN(3, 10, 10), IA(10), IB(10), SEGM(10)
DIMENSION IREC(10), IFN(10), IGS(10), NAS(10)
DIMENSION NSA(10), VG(10), ZLD(10), IFM(10)
DIMENSION IABFP(10), IABAP(10)
DIMENSION VLG(10), ZL(10)

CHARACTER *1 USEWR, GEOPRT, DFLT, FARZ, USEPLT, MCOUPL, WRTIMP
CHARACTER *1 CHFREQ, CHCPAT, CHGRAD, CHGCON, Change
Character*40 Filename, Variable
Character*1 Answer

COMPLEX VLG
COMPLEX ZL
COMPLEX VGA
COMPLEX ZLDA
Complex*8 Zsht(30)

WRITE(*, 10)
WRITE(*, 20)
WRITE(*, 30)
10 FORMAT('This program (ESP4.) is based on the method of moments')
20 FORMAT('**************')
30 FORMAT('')

WRITE(*, 2000)
2000 FORMAT(1H3, 'Do you wish to change an existing input file? (Y/N)' )

READ(*, 50) CHGFIL
IF( CHGFIL .EQ. 'N' .OR. CHGFIL .EQ. 'n' ) GOTO 8

WRITE(*, 2011)
2011 Format(1H3, 'Enter the filename to edit: ')

Read(*, 431) Filename
431 format(A40)

Open( Unit=10, File=Filename, Status='old')
ICHG=0

READ IN VALUES FROM EXISTING DATA FILE
READ(10, *) NGO, NPRINT, MRUNS, NWGS, IWR, IWRZT, INT, INTP, INTD, INNR, IRGM, IFIL, RF, INDZI

If( Indzi .ne. 0) Then
  Read(10, *) Fmc1, Fmc2, Dfzi, Dff, Irs12, Thrd, Phrd,
           Thinc, Phinc
End if

If( Indzi .eq. 0) Then
  READ(10, *) IFE, IPFE, FNDFE, PHFE
  READ(10, *) IFA, IPFA, FNDSA, THFA
  READ(10, *) ISE, IPSE, FNDS, PHSE, THIN, PHIN
  READ(10, *) ISA, IPSA, FNDSA, THSA
End if

READ(10, *) FMC, CNM, A

IF(USEPLT .ne. 'N' .OR. USEPLT .ne. 'n') Then
  READ(10, *) NPLTS
  IF( Nplts .ne. 0) Then
    DO 1520 NPL=1, NPLTS
        READ(10, *) NCNRS(NPL), SCNM(NPL), IREC(NPL), IPN(NPL),
                      IGS(NPL), Zshf(Npl)
    DO 1510 NCNR=1, WCNRs(NPL)
         READ(10, *) PCN(1, NCNR, NPL), PCN(2, NCNR, NPL),
                       PCN(3, NCNR, NPL)
  1510 CONTINUE
  1520 CONTINUE
End if

IF(USEWRS .EQ. 'N' .OR. USEWRS .EQ. 'n') GOTO 810
READ(10, *) IWRZM, IRDMZ

IF( Inur .ne. 0 .AND. Irgr .ne. 0) Then
  READ(10, *) NM, NP, NAT, NFPT, NFS1, NFS2
  DO 1550 I=1, NP
      READ(10, *) X(I), Y(I), Z(I)
  1550 CONTINUE

  DO 1560 I=1, NM
      READ(10, *) IA(I), IB(I)
           write(*,*) ia(i), ib(i)
  1560 CONTINUE

  DO 1570 I=1, NFPT
      READ(10, *) IFM(I), IABFP(I), VLG(I), Z(L(I)
           write(*,*) IFM(I), IABFP(I), VLG(I), ZL(I)
  1570 CONTINUE

  DO 1580 I=1, NAT
      READ(10, *) NAS(I), IABAP(I), NPLA(I), VGA(I), ZLDA(I), BDSK(I)
           write(*,*) NAS(I), IABAP(I), NPLA(I), VGA(I), ZLDA(I), BDSK(I)
  1580 CONTINUE
End if

REWIND 10

END OF READING OF DATA FILE

Variable = 'Frequency'
Call Rchange(Variable, FMC, 0)

3200 FORMAT(/)

2002 IF(USEWRS .EQ. 'N' .OR. USEWRS .EQ. 'n') GOTO 2006
If ( Nwgs .gt. 0) Then

Variable = 'Wire Radius'
Call Rchange( Variable, A, 0)

Variable = 'Wire Conductivity'
Call Rchange( Variable, Cmm, 0)

End if

If( INDZI .ne. 0) then

Write(*,*) 'The current values for Frequency Sweep are:
write(*,5010) Fmcl, Fmc2, Dfzi, Dff, Irs12, Thrd, Phrd, Thri, Phri

Format(5x,'1 -Begin of sweep (MHz)',F8.2,/
   5x,'2 -End of sweep (MHz)',F8.2,/
   5x,'3 -Step size for Impedance Matrix (MHz)',F8.2,/
   5x,'4 -Step size for MM computation (MHz)',F8.2,/
   5x,'5 -Indicator of radiation or scattering problem',I2,/
   10x,' 1 - Implies radiation problem',/
   10x,' 2 - Implies scattering problem',/
   10x,'-2 - Implies scattering including incident wave',/
   5x,'6 -Angle for radiated or scattered field (Degrees)',/
   10x,'Theta = ',F8.2,5x,'Phi = ',F8.2,/
   5x,'7 -Angle of incident for scattering problem (Degrees)',/
   10x,'Theta = ',F8.2,5x,'Phi = ',F8.2/

Write(*,6050)
Read(*,50) Answer.
If (Answer .eq. 'y', or. Answer .eq. 'Y') Then

Write(*,2035)
Read(*,50) I

If( I .eq. 1 ) then
   Variable = 'Beginning of Sweep (MHz)'
   Call Rchange( Variable, Fmcl, 0)
Else if( I .eq. 2 ) then
   Variable = 'End of Sweep (MHz)'
   Call Rchange( Variable, Fmc2, 0)
Else if( I .eq. 3 ) then
   Variable = 'Step Size for Z matrix (MHz)'
   Call Rchange( Variable, Dfzi, 0)
Else if( I .eq. 4 ) then
   Variable = 'Step Size for MM Computation (MHz)'
   Call Rchange( Variable, Dff, 0)
Else if( I .eq. 5 ) then
   Variable = 'Radiation or Scattering Problem'
   Call Ichange( Variable, IRS12, 0)
   J = Irs12
   if( J .ne. 1 .or. j .ne. 2 .or. j .ne. -2 ) then
      Write(*,*) 'Input out of range. Try again'
      Goto 5025
   End if
Else if( I .eq. 6 ) then
   Variable = 'Theta'
   Call Rchange( Variable, Thrd, 0)
   Variable = 'Phi'
   Call Rchange( Variable, Phrd, 0)
Else if( I .eq. 7 ) then
   Variable = 'Theta'
   Call Rchange( Variable, Thri, 0)
   Variable = 'Phi'

5025
Call Rchange( Variable, Phri, 0)
End if
Goto 5020
End if
Else
Write(*, 6020) Ife, Ipfe, Fndfe, Phfe
6020 Format(' The current values of Pattern Data are: ', /)
   5x, '1 -Compute near or far zone elevation radiation pattern', I2/,
   5x, '2 -Write elevational pattern to plot file', I2/,
   5x, '3 -Elevation angle increment (Deg)', F8.2/,
   5x, '4 -Constant phi elevational angle (Deg)', F8.2/
End if
Else
&,
End if
Write(*, 6030) Ifa, Ipfa, Fndfa, Thfa
6030 Format('5x, '5 -Compute near or far zone azimuth radiation pattern',
   I2/, 5x, '6 -Write azimuthal pattern to plot file', I2/,
   5x, '7 -Azimuth angle increment (Deg)', F8.2/,
   5x, '8 -Constant theta azimuthal angle (Deg)', F8.2/
End if
End if
Write(*, 6050)
6050 Format('5x, '5 -Would you like to change any of these? ',)
Read(*, 50) Answer
End if
Write(*, 6060)
6060 Format('Scattering Section: ', /)
Write(*, 6070) Isa, Ipse, Fndse, Phse
6070 Format('5x, '1 -Type of Scattering in Elevation Plane: ', I2/, 10x,
   '0 -Do not compute backscatter', /10x,
   '1 -Compute Backscatter pattern', /10x,
   '2 -Compute Bistatic scattering pattern', /10x,
   '3 -Computer Forward scattering pattern', /
   5x, '2 -Write scattering pattern to Plot file', I2/,
   5x, '3 -Angle increment for scattering', F8.2/,
   5x, '4 -Constant Phi angle (Deg) for scattering', F8.2/
End if
Write(*, 6080) Isa, Ipsa, Fndsa, Thsa
6080 Format('5x, '5 -Type of Scattering in Azimuthal Plane: ', I2/,
   5x, '6 -Write scattering pattern to Plot file', I2/,
   5x, '7 -Angle increment for scattering', F8.2/,
   5x, '8 -Constant Theta angle (Deg) for scattering', F8.2/
End if
Write(*, 6040) Thin, Phin
6040 Format('5x, '9 -Theta angle (deg) of incident wave in Bistatic',
   'Scattering', F8.2/,
   4x, '10 -Phi angle (deg) of incident wave in Bistatic',
   'Scattering', F8.2/
Write(*, 6050)
Read(*, 50) Answer
End if
End if
2009 WRITE(*, 2010)
2010 FORMAT(1H$, 'Would you like to change the Plate Data? (Y/N) ')
READ(*, 50) Answer
IF (Answer .eq. 'Y' .OR. Answer .eq. 'y') Then
Write(*, 2720)
2720 Format(1H$, 'Your choice: ')
Read(*,*)

If(I.eq.1) Then

NPLTS = NPLTS + 1
NPL = NPLTS
Ichg = 1
CALL PLATE(NPL, NCNRS, SEGM, IREC, IPN, IGS, PCN, ICHG, Zsht)

Else

WRITE(*,2030) NPLTS
Format(1H$,'There are now',I2,' plates. ')
WRITE(*,2035)
Format(1H$,'Which would you like to change? ')
READ(*,*) NPL
Ichg = 0
CALL PLATE(NPL, NCNRS, SEGM, IREC, IPN, IGS, PCN, ICHG, Zsht)

End if
End if

WRITE(*,2060)
Format(1H$,'Would you like to change the Wire Data? (Y/N) ')
READ(*,30) Answer
IF(Answer.eq.'Y' OR Answer.eq.'y') Then
Ichg = 0
CALL WIRE(NM, NP, NAT, NFPT, NSF1, NSF2, ICHG)
End if
GOTO 910

*********** END OF CHANGE SECTION; BEGIN ORIGINAL INPUT ***********

ICHG=1
Write(*,310)
310 Format(1H$,'Enter the filename to write: ')
Read(*,431) Filename
OPEN(Unit=10, File=Filename, Status='new')

WRITE(*,12)
12 Format(1H$,'Do you wish to specify any of the following',
' parameters? (Y/N) '/)

WRITE(*,14)
14 Format(10X,'* Number of runs to be made'/10X,
' * Print of modal currents'/10X,
' * Print of impedance matrix'/10X,
' * Define frequency sweep'/10X,
' * Number of Simpsons-rule intervals for: '/15X,
' * Wire-to-wire impedances'/15X,
' * Surface-patch monopoles'/15X,
' * Disk monopoles'/)

READ(*,50)DFLT

IF(DFLT.EQ.'Y' OR DFLT.EQ.'y') Then
Variable = 'Number of Runs'
Call Ichange(Variable, Nruns, Ichg)

Variable = 'Number of Wire Geometries per Run'
Call Ichange(Variable, Nwgs, Ichg)
WRITE(*, 1025)
1025 FORMAT(/1X, 'MODAL CURRENT PRINTOUT: '/6X,
     '0 NO MODAL CURRENT PRINTOUT'/6X,
     '1 MODAL CURRENTS PLUS WIRE/PLATE GEOMETRY PRINTED')
Variable = 'Modal Current Printout'
Call Ichange( Variable, Iwr, Ichg)

WRITE(*, 1030)
1030 FORMAT(/1X, 'WRITE IMPEDANCE MATRIX IN OUTPUT FILE? (Y/N)'
READ(*, 50) WRTIMP

IF(WRTIMP.EQ. 'Y'. OR. WRTIMP.EQ. 'y') Then
   IWRZT=1
Else
   IWRZT=0
End if

WRITE(*, 1040)
1040 FORMAT(/1X, 'NUMBER OF SIMPSONS-RULE INTEGRATION INTERVALS: '/6X,
     '1 FOR WIRE-TO-WIRE IMPEDANCES?')
READ(*, *) INT
WRITE(*, 1050)

WRITE(*, 1060)
1060 FORMAT(/1X, 'FOR SURFACE-PATCH MODULES?')
READ(*, *) INTP
WRITE(*, 1070)

1070 FORMAT(/1X, 'HOW IS THE WIRE GEOMETRY DEFINED?'/10X,
     '0 BY SUBROUTINE WGEOM'/10X,
     '1 DEFINED VIA THE INPUT FILE')
READ(*, *) IRGM
Else

--- APPLY DEFAULT VALUES ---

READ 1:
NRUNS=1
NWGS=1
IWR=0
IWRZT=1
INT=4
INTP=6
INTD=18
IRGM=1
End if

--- INPUT NON-DEFAULT INFORMATION ---

WRITE(*, 40)
40 FORMAT(/1X, 'DOES THE MODEL CONTAIN WIRES? (Y/N)'
READ(*, 50) USEWRS
WRITE(*, 45)
45 FORMAT(/1X, 'DOES THE MODEL CONTAIN PLATES? (Y/N)'
READ(*, 50) USEPLT

50 FORMAT(A1)
IF(USEWRS.EQ. 'Y'. OR. USEWRS.EQ. 'y') INWR=1
WRITE(*,60)
60 FORMAT(/1X,'SPECIFY REQUIRED OUTPUT: '/10X,
   ' 1 PRINT WIRE & PLATE GEOMETRY'/10X,
   ' 2 PRINT INPUT PARAMETERS & WIRE/PLATE GEOMETRY'/10X,
   ' 3 PRINT NOTHING')
C
READ(*,*) NPRINT
C
WRITE(*,70)
70 FORMAT(/1X,'DO YOU WANT TO PRINT INPUT DATA BEFORE COMPUTING?')
READ(*,50) IFIRST
IF(IFIRST.EQ.'Y'.OR.IFIRST.EQ.'y') THEN
   NGO=0
ELSE
   NGO=1
ENDIF
C
WRITE(*,710)
710 Format(1H$,'Do you want a Frequency Sweep?')
READ(*,50) Answer
IF( Answer .eq. 'Y' .or. Answer .eq. 'y') then
   WRITE(*,720)
720 Format(' 1 - Frequency sweep with impedance matrix ','interpolation method',/ ' 2 - Frequency sweep with ','"improved" impedance matrix interpolation method')
   WRITE(*,725)
725 Format(1H$,'Which would you prefer?')
READ(*,*) INDZI
C
Variable = 'Beginning of Sweep (MHz)'
Call Rchange( Variable, Fmc1, 1)
C
Variable = 'End of Sweep (MHz)'
Call Rchange( Variable, Fmc2, 1)
C
Variable = 'Step Size for Z matrix (MHz)'
Call Rchange( Variable, Dfzi, 1)
C
Variable = 'Step Size for MM Computation (MHz)'
Call Rchange( Variable, DFF, 1)
C
WRITE(*,730)
730 Format(' Indicator of radiation or scattering problem',/ 10x, ' 1 - Implies radiation problem',/ 10x, ' 2 - Implies scattering problem',/ 10x, ' -2 - Implies scattering including incident wave')
Variable = 'Radiation or Scattering Problem'
Call Ichange( Variable, IRS12, 0)
J = IRS12
IF( J .ne. 1 .or. J .ne. 2 .or. J .ne. -2 ) then
   WRITE(*,*) 'Input out of range. Try again'
   GOTO 730
End if
C
WRITE(*,740)
740 Format(' Angle for Computing Radiated or Scattered Field ',/ (Deg)')
Variable = 'Theta'
Call Rchange( Variable, Thrd, 1)
Variable = 'Phi'
C
Call Rchange( Variable, Phrd, 1)

Write(*,*) 'Angle of Indicent Plane Wave of Scattering (Deg)'
Variable = 'Theta'
Call Rchange( Variable, Thri, 1)
Variable = 'Phi'
Call Rchange( Variable, Phri, 1)

Else
INDZI = 0
WRITE(*, 80)
80 FORMAT(/1X, 'SPECIFY TYPE OF PATTERN CUT'/10X,
       '1 GREAT-CIRCLE CUT (VARIABLE THETA)'/10X,
       '2 CONICAL CUT (VARIABLE PHI)'/
READ(*,*) ICUT
WRITE(*, 90)
90 FORMAT(/1X, 'FAR-ZONE ANTENNA PATTERN? (Y/N)'
READ(*, 50) FARZN
WRITE(*, 110)
110 FORMAT(/1X, 'VALUE OF CONSTANT ANGLE:'
READ(*,*) CONANG
WRITE(*, 130)
130 FORMAT(/1X, 'ANGLE INCREMENT?'
READ(*,*) ANGINC
WRITE(*, 120)
120 FORMAT(/1X, 'DO YOU WANT AN OUTPUT FOR PLOTTING? (Y/N)'
READ(*, 50) PLTOUT

IF( FARZN .EQ. 'N' .OR. FARZN .EQ. 'n' ) Then

PARAMETER VALUES SET FOR FAR-ZONE RADIATION
PATTERN FOR BOTH TYPES OF PATTERN CUT

Variable = 'Radius for Field Point (meters)'
Call Rchange( Variable, RF, 1)
IF=0
IPFE=0
FNDFE=1
PHFE=1.0
IFA=0
IPFA=0
FNDFA=1
THFA=1.0

--- INPUT MATRIX DOES NOT EXIST FOR THIS CASE ---
IWRZT=0

--- PLATES ARE MODELED AS PERFECT CONDUCTORS ---
CMM=-1.0

--- "WIRE RADIUS" SET TO .001 FOR PLATE ---
A=.001

--- INFORMATION INPUT FOR PLANE-WAVE SCATTER ---
WRITE(*,160)
160 FORMAT(/1X, 'SPECIFY TYPE OF SCATTER COMPUTATION: '/10X,
        '1 BACKSCATTER'/10X,
        '2 BISTATIC SCATTER'/10X, '3 FORWARD SCATTER')
READ(*,*) ITYPE
IF(ICUT.EQ.1) THEN
  ISE=ITYPE
  ISA=0
ELSE
  ISE=0
  ISA=ITYPE
ENDIF

IF(PLTOUT.EQ.'Y',OR.PLTOUT.EQ.'y') THEN
  IPSE=1
  IPSA=1
ELSE
  IPSE=0
  IPSA=0
ENDIF

-- INPUT ANGLE INCREMENTS FOR PLANE-WAVE SCATTER ----
FNDSE=ANGINC
FNDSA=ANGINC

--- INPUT CONSTANT ANGLE FOR PLANE-WAVE SCATTER ---
PHSE=CONANG
THSA=CONANG

--- INPUT ANGLE OF INCIDENCE ---
WRITE(*,170)
FORMAT(/1X,'WHAT IS THE ANGLE OF INCIDENCE? (THETA, PHI)')
READ(*,*) THIN,PHIN

Else

--- PARAMETERS SET FOR PLANE-WAVE SCATTER CASE ---
RF = -1
ISE=0
IPSE=0
FNDSE=1
PHSE=1.0
THIN=1.0
PHIN=1.0
ISA=0
IPSA=0
FNDSA=1
THSA=1

--- CONSTANT ANGLE VALUE IS SET FOR EITHER PATTERN CUT ---
PHFE=CONANG
THFA=CONANG

--- TYPE OF PATTERN CUT IS SET ---
IF(ICUT.EQ.1) THEN
  IFE=1
  IFA=0
ELSE
IFE=0
IFA=1
ENDIF

--- OUTPUT DESIGNATION & ANGLE INCREMENT VALUE ---

IF(PLTOUT.EQ.'Y'. OR. PLTOUT.EQ.'y') THEN
  IPFE=1
  IPFA=1
ELSE
  IPFE=0
  IPFA=0
ENDIF

FNDFE=ANGINC
FNDFA=ANGINC

End if
End if

--- INPUT FREQUENCY ---

175 WRITE(*,180)
180 FORMAT(1X, 'FREQUENCY IN MEGAHERTZ?')
READ(*,*) FMC

--- INPUT WIRE CONDUCTIVITY & RADIUS IF WIRES USED ---

IF(USEWRS.EQ.'N'. OR. USEWRS.EQ.'n') then

--- SUPPLY FICTITIOUS NUMBERS FOR WIRE PARAMETERS ---

210  CMM=-1.0
     A=0.001

Else
  WRITE(*,190)
190 FORMAT(1X, 'WIRE CONDUCTIVITY IN MEGAMHOS/METER?')
READ(*,*) CMM
WRITE(*,200)
200 FORMAT(1X, 'WIRE RADIUS IN METERS?')
READ(*,*) A
End if

215 IF( USEPLT .EQ. 'Y' . OR. USEPLT .EQ. 'y') Then

--- INPUT PLATE INFORMATION ---

220 FORMAT(1X, 'HOW MANY PLATES?')
READ(*,*) NPLTS

WRITE(*,225)
225 FORMAT(1X, 'INPUT TYPE OF PLATE TEST MODE: '/10X,
     '0 FULL-SURFACE PATCH MODE'/10X,
     '1 FILAMENTARY TEST MODE')
READ(*,*) IFIL

WRITE(*,230)
DO 420 NPL=1, NPLTS
   CALL PLATE(NPL, NCNRS, SEGMR, IREC, IPN, IGS, PCN, ICHG, Zsht)
420   CONTINUE
End if

--- REUSE OF IMPEDANCE MATRIX ---
Disk storage of impedance is not anticipated; therefore:
IWRZM=0
IRDZM=0

IF( USEWRS .EQ. 'Y' .OR. USEWRS .EQ. 'y') Then

--- INPUT WIRE INFORMATION ---
CALL WIRE(NM, NP, NAT, NFPT, NSF1, NSF2, ICHG)
CALL WRPTS(I, NP, X, Y, Z, ICHG)
CALL ENDPT(NM, IA, IB, ICHG)
CALL FPPLT(NFPT, IFM, IABFP, VLG, ZL, ICHG)

DO 700 I=1, NAT
   CALL FPNPL(I, NAS, IABAP, NPLA, VGA, ZLDA, BDKS, ICHG)
700   CONTINUE
End if

--- PARAMETER VALUES WRITTEN TO DATA FILE ---
WRITE(10,100) NGO, NPRINT, NRUNS, NWGS, IWR, IWRZT, INT, INTP,
        INTD, INWR, IRGM, IFIL, RF, Indzi
100 FORMAT(2I2,2I2,3I2,3I2,F6.2,I4)
   IF( Indzi .ne. 0) Then
      WRITE(10,*) Fmc1, Fmc2, Dfzi, Dff, Irs12, Thrd, Phrd,
              Thinc, Phinc
   End if
   IF( Indzi .eq. 0) Then
      WRITE(10,910) IFE, IPFE, FNDFE, PHFE
      WRITE(10,910) IFA, IPFA, FNDFA, THFA
      WRITE(10,910) ISA, IPSA, FNSA, THSA
      WRITE(10,920) FMC, CMM, A
   End if
910  FORMAT(2I2,4F6.2)
920  Format(2FB.2,FB.4)

IF(USEPLT. EQ. 'N'. OR. USEPLT. EQ. 'n') Then

WRITE(10,*) 0
WRITE(10,*) 4, 0.2, 1, 3, 0
   DO I=1,4
      WRITE(10,*) 1.0, 1.0, 1.0
   End do
Else
   WRITE(10,*) NPLTS
   DO NPL=1, NPLTS
      WRITE(10,930) NCNRS(NPL), SEGMR(NPL), IREC(NPL), IPN(NPL),
                           IGS(NPL), Zsht(Np1)
930   Format(I3,F6.3,3I3,'(',F6.2,','F6.2,')')
      DO NCNR=1, NCNRS(NPL)
WRITE(10,940) PCN(1,NCNR,NPL), PCN(2,NCNR,NPL), PCN(3,NCNR,NPL)

End do
End do
End if

--- INPUT FILLER NUMBERS FOR NO-PLATES CASE ---

WRITE(10,*), IWRZM, IRDMZ

--- DO NOT WRITE WIRE INFORMATION TO FILE FOR NO-WIRES CASE ---

If(Inwr.ne.0.and.Irgm.ne.0) Then
  WRITE(10,950) NM,NP,NAT,NFPT,NFS1,NFS2
End if

DO I=1,NP
  WRITE(10,960) X(I),Y(I),Z(I)
End do

DO I=1,NM
  WRITE(10,950) IA(I),IB(I)
End do

IF( NFPT.GT.0) Then
  DO I=1,NFPT
    WRITE(10,970) IFM(I),IABFP(I),VLG(I),ZL(I)
  End do
Else
  WRITE(10,970) 1.0,(1.0,1.0),(1.0,1.0)
End if

DO I=1,NAT
  WRITE(10,980) NAS(I),IABAP(I),NPLA(I),VGA(I),ZLDA(I),BDK(I)
End do

Subroutine Rchange ( Variable, Value, New)

Character*1 Change
Character*40 Variable
Real*4 Value
Integer*4 New

n = 1
Do while( Variable(n:n+1).ne."")
  n = n + 1
End do
n = n - 1
if( New .eq. 0) then
  Write(*,10) Variable(1:n), Value
  Format(1H$, 'The current value of ',A<n>, ' is ',F6.2)
else
  Format(1H$, 'Would you like to change this value? ')
  Read(*,30) Change
end if

If( Change .eq. 'y' .or. Change .eq. 'Y') Then
  Write(*,40) Variable(1:n)
  Format(1H$, 'Please enter the new value for ',A<n>, ' ')
  READ(*,*) Value
end if

Write(*,100)
Format(A1)
100 Format(/)
Return
End

Subroutine Change ( Variable, Value, New)

Character*1 Change
Character*40 Variable
Complex*8 Value
Integer*4 New

n = 1
Do while( Variable (n:n+1) .ne. ' ')
  n = n + 1
End do
n = n - 1

if( New .eq. 0) then
  Write(*,10) Variable(1:n), Value
  Format(1H$, 'The current value of ',A<n>, ' is ',
        '(','F6.2',',','F6.2',')')
else
  Format(1H$, 'Would you like to change this value? ')
  Read(*,30) Change
end if

If( Change .eq. 'y' .or. Change .eq. 'Y') Then
  Write(*,40) Variable(1:n)
  Format(1H$, 'Please enter the new value for ',A<n>, ' ')
  READ(*,*) Value
end if

Write(*,100)
Format(A1)
Subroutine Ichange (Variable, Ivalue, New)

Character*1 Change
Character*40 Variable
Integer*4 New
Integer*4 Ivalue

n = 1
Do while (Variable (n:n+1) ne. ' ' . and. n .lt. 40)
    n = n + 1
End do
n = n - 1

if( New .eq. 0) then
    Write(*,10) Variable(1:n), Ivalue
    Format(1H$, 'The current value of ', A<n>, ' is ', I5)
    Write(*,30)
    Format(1H$, 'Would you like to change this value? ')
    Read(*,50) Change
else
    Change = 'y'
End if

If( Change .eq. 'y' .or. Change .eq. 'Y') Then
    Write(*,40) Variable(1:n)
    Format(1H$, 'Please enter the new value for ', A<n>, ' ')
    Read(*,*>) Ivalue
End if

Write(*,100)
Format(A1)
100 Format(//)
Return
End

SUBROUTINE PLATE( NPL, NCNRS, SEGM, IREC, IPN, IGS, PCN, ICHG, Zsht)

DIMENSION NCNRS(10), SEGM(IO), IREC(IO), IGS(IO), IPN(IO), PCN(3,10,10)
Complex*8 Zsht(10)
Character*40 Variable

WRITE(*,240) NPL
240 FORMAT(1X, 'For PLATE NUMBER ', I3)

Variable = 'Number of Corners'
CALL ICHange( Variable, NCNRS(NPL), ICHG)

Variable = 'Size of Patch'
CALL RCHange( Variable, SEGM(NPL), ICHG)

WRITE(*,254)
254 FORMAT(1X,'IDENTIFY SHAPE OF PLATE -'/
     10X,'0 POLYGONAL'/
     10X,'1 RECTANGULAR'/)
Variable = 'Shape of Plate'
CALL ICHANGE( Variable, IREC(NPL), ICHG)

*** POLARIZATION SELECTION IS SET TO 3 FOR ALL CASES ***
IPN(NPL)=3

WRITE(*,256)
256 FORMAT(1X,'WHICH IS THE GENERATING SIDE?')
Variable = 'The Generating Side'
CALL ICHANGE( Variable, IGS(NPL), ICHG)

WRITE(*,500)
500 Format(1X,'The complex Sheet Impedance must be set to zero',
     'if the plate contains', ', a wire/plate attachment')
Variable = 'Sheet Impedance'
Call CCHANGE( Variable, Zsht(Npl1, Ichg)

WRITE(*,260)
260 FORMAT(1X,'INPUT POSITION OF EACH CORNER (X, Y, Z)'

DO 275 NCNR=1, NCNRS(NPL)
     WRITE(*,270) NCNR
270 FORMAT(1X,'NO. ',13)
Variable = 'X coordinate'
CALL RCHANGE( Variable, PCN(1,NCNR,NPL), Ichg)
Variable = 'Y coordinate'
Call Rchange( Variable, PCN(2,NCNR,NPL), Ichg)
Variable = 'Z coordinate'
Call Rchange( Variable, PCN(3,NCNR,NPL), Ichg)
275 CONTINUE
RETURN
END

SUBROUTINE WIRE(NM, NP, NAT, NFPT, NSF1, NSF2, ICHG)

Character*40 Variable
Character*1 Mcoupl

Variable = 'the Number of Wire Segments'
CALL ICHANG(E(Variable, NM, ICHG)

Variable = 'Total No. of Points in Wire Structure'
CALL ICHANG(E(Variable, NP, ICHG)

Variable = 'Number of Wire-to-Plate attachment pts.'
CALL ICHANG(E(Variable, NAT, ICHG)

Variable = 'Number of Feed Pts. in Wire Structure'
CALL ICHANG(E(Variable, NFPT, ICHG)

WRITE(*,470)
470 FORMAT(1H#, 'IS MUTUAL COUPLING TO BE COMPUTED?')
READ(*,50) MCOUPL
50 FORMAT(A1)
      IF(MCOUPL.EQ.'Y'.OR.MCOUPL.EQ.'y') Then
         Variable = 'location of First Feed Port'
         CALL ICHANGE(Variable, NSF1, ICHG)
      ENDIF

      Variable = 'location of Second Feed Port'
      CALL ICHANGE(Variable, NSF2, ICHG)
      ELSE
         NSF1=0
         NSF2=0
      END if
      RETURN
      END

SUBROUTINE WRPTS(I,NP,X,Y,Z,ICHG)
DIMENSION X(10),Y(10),Z(10)

      Character*40 Variable
      WRITE(*,520)
520 FORMAT(/1X,'INPUT LOCATIONS (X,Y,Z) OF WIRE POINTS: ')
      DO 530 I=1,NP
         WRITE(*,525) I
525 FORMAT(/1X,'For POINT ',I3)
         Variable = 'X coordinate'
         CALL RCHANGE( Variable, X(I), ICHG)
         Variable = 'Y coordinate'
         CALL RCHANGE( Variable, Y(I), ICHG)
         Variable = 'Z coordinate'
         CALL RCHANGE( Variable, Z(I), ICHG)
      CONTINUE
      RETURN
      END

SUBROUTINE ENDPT(NM,IA,IB,ICHG)
DIMENSION IA(10),IB(10)

      Character*40 Variable
      WRITE(*,535)
535 FORMAT(/1X,'INPUT ENDPOINT A & ENDPOINT B OF EACH WIRE SEGMENT: / ')
      DO 550 J=1,NM
         WRITE(*,540) J
540 FORMAT(/1X,'For SEGMENT ',I3)
         Variable = 'Endpoint A'
         CALL ICHANGE( Variable, IA(J), ICHG)
         Variable = 'Endpoint B'
         CALL ICHANGE( Variable, IB(J), ICHG)
      CONTINUE
      RETURN
      END

SUBROUTINE FPPLT(NFPT,IFM,IABFP,VLG,ZL,ICHG)
DIMENSION IFM(10),IABFP(10),VLG(10),ZL(10)
COMPLEX VLG
COMPLEX ZL

Character*40 Variable

WRITE(*, 560)
560 FORMAT(/1X, 'INPUT LOCATIONS OF FEED POINTS: '/)
DO 650 I=1, NFPT
  WRITE(*, 570) I
570 FORMAT(1X, 'FEED POINT NO. ', I3, ' is in which Wire Segment?')
  Variable = 'Wire Segment'
  CALL ICtHANGE( Variable, IFM(I), ICHG)
  WRITE(*, 580)
580 FORMAT(1X, 'AT WHICH END OF SEGMENT?'/10X,
         '0 ENDPOINT A'/10X,
         '1 ENDPOINT B'/)
  Variable = 'Endpoint'
  CALL ICtHANGE( Variable, IABFP(I), ICHG)
C
Variable = 'Generator Complex Voltage at Feed Point'
  Call Cchange( Variable, VLG(I), Ichg)
C
Variable = 'Complex Load Impedance (ohms)'
  Call Cchange( Variable, ZL(I), Ichg)
C
650 CONTINUE
RETURN
END

C

SUBROUTINE FPNPtL(NAT, NAS, IABAP, NPLA, VGA, ZLDA, BDSK, ICHG)
DIMENSION NAS(10), IABAP(10), NPLA(10), BDSK(10)
C
Complex Zlda(I, Vga(I)
Character*40 Variable
C
IF(NAT .EQ. 0) Return
C
DO 700 I=1, NAT
  Variable = 'No. of wire segments attached to plate'
  CALL ICtHANGE( Variable, NAS(I), ICHG)
C
  WRITE(*, 660)
660 FORMAT(/1X, 'ENDPOINT ATTACHED TO PLATE: '/10X,
         '0 POINT A'/10X,
         '1 POINT B')
  Variable = 'Endpoint'
  CALL ICtHANGE( Variable, IABAP(I), ICHG)
C
Variable = 'Plate Number'
  CALL ICtHANGE( Variable, NPLA(I), ICHG)
C
Variable = 'Attachment Pt Complex Generator Voltage'
  Call Cchange( Variable, VGA(I), Ichg)
C
Variable = 'Attachment Point Complex Load Impedance'
  Call Cchange( Variable, ZLDA(I), Ichg)
C
Variable = 'Disk Radius (meters)'

41
Call Rchange( Variable, Bdsk(i), Ichg)

700 CONTINUE
RETURN
END
APPENDIX B

GRAPHICS CODES
PROGRAM PLTGTD
IMPLICIT INTEGER*2(I-N)
DIMENSION ANG(600)
DIMENSION AMP(600)
DIMENSION ASTEP(5)
DIMENSION XPLT(361,7)
CHARACTER*1 Z,CHCUT,HOLDIT,NEXTP

OPEN(2,FILE='PRN')

WRITE(*,70)
70 FORMAT(1X,'THE PATTERN IS READY TO BE PLOTTED'//)

INPUT THE TYPE OF POLARIZATION COMPONENT DESIRED

IF(IPOL.EQ.1) KPOL=6
IF(IPOL.EQ.2) KPOL=7
IF(IPOL.EQ.3) KPOL=3
IF(IPOL.EQ.4) KPOL=4
IF(IPOL.EQ.5) KPOL=5

READ(*,*) IPOL

ASSOCIATE DATA COLUMNS WITH POLARIZATION DESIGNATIONS

READ DATA FROM FILE PLOT.DAT TO ARRAY XPLT

COUNT POINTS AS READING PROCEEDS
NUMPNT=NUMPNT+1

CONTINUE
200 CONTINUE
DETERMINE TYPE OF PATTERN CUT (GREAT CIRCLE OR CONICAL)

CHCUT='Y' FOR GREAT-CIRCLE CUT; CHCUT='N' FOR CONICAL CUT

VAL1=XPLT(2,1)
VAL2=XPLT(1,1)
CHCUT='N'
IF(ABS(VA2-VAL1).GT.0.01) CHCUT='Y'

SET MINIMUM AND MAXIMUM VALUES OF ANGLE

IF(CHCUT.EQ.'Y') THEN
  AFST=XPLT(1,1)
  ALST=(XPLT(3,1)-XPLT(2,1))*(NUMPNT-1)+XPLT(1,1)
  NCUT=1
ENDIF

IF(CHCUT.EQ.'N') THEN
  AFST=XPLT(1,2)
  ALST=XPLT(NUMPNT,2)
  NCUT=2
ENDIF

ANGDIFF=XPLT(2,NCUT)-XPLT(1,NCUT)

TRANSFER DATA FROM XPLT ARRAY TO ANG AND AMP ARRAYS

ANG(0)=0.0

DO 80 I=1,NUMPNT
  ANG(I)=XPLT(I,NCUT)
  IF(ANG(I).LT.ANG(I-1)) THEN
    ANG(I)=ANG(I-1)+ANGDIFF
  ENDIF
  AMP(I)=XPLT(I,KPOL)
  IF(AMP(I).LT.-50.) AMP(I)=-50.
80 CONTINUE

FIND AMPMIN AND AMPMAX VALUES

AMPMIN=-10.
AMPMAX=10.

DO 20 I=1,NUMPNT
  IF(AMP(I).GT.AMPMAX) AMPMAX=AMP(I)
  IF(AMP(I).LT.AMPMIN) AMPMIN=AMP(I)
20 CONTINUE

25 ASPECT=(ALST-AFST)/(AMPMAX-AMPMIN)

ROUND OFF AMPMIN & AMPMAX VALUES

AMPMIN=INT(AMPMIN)
AMPMAX=INT(AMPMAX)

DETERMINE BEST ANGLE AND AMPLITUDE INCREMENTS TO USE
XINC=(ALST-AFST)/10.
YINC=(AMPMAX-AMPMIN)/10.

STEP(1)=1.
STEP(2)=2.
STEP(3)=5.
STEP(4)=10.
STEP(5)=30.

DO 30 I=1,5
XSTEP=STEP(I)
IF(XSTEP.GT.XINC) GOTO 40
CONTINUE

40 XMAJOR=XSTEP

DO 50 I=1,4
YSTEP=STEP(I)
IF(YSTEP.GT.YINC) GOTO 55
CONTINUE

55 YMAJOR=YSTEP
ISTEP=INT(YSTEP)

NSTEP=AMPMIN/ISTEP
IF(AMPMIN.LT.-50.) GOTO 58
AMPMIN=NSTEP*ISTEP-ISTEP
GOTO 350

58 AMPMIN=NSTEP*ISTEP

350 CALL QSETUP(0,3,-2,0)

60 CALL QPLOT(JCL1,JCL2,JROW1,JROW2,AFST,ALST,AMPMIN,AMPMAX,AFST,AMPMIN,IOPT,1.,ASPECT)
CALL QSMODE(6)

YMAX=AMPMAX+0.1*(AMPMAX-AMPMIN)
CALL QXAXIS(AFST,ALST,XMAJOR,MINOR,LABEL,NDEC)
CALL QYAXIS(AMPMIN,YMAX,YMAJOR,MINOR,LABEL,NDEC)
IF(CHCUT.EQ.'Y') GOTO 300
CALL QTXTA(12,'PHI, DEGREES',2)
GOTO 400

300 CALL QTXTA(14,'THETA, DEGREES',2)
400 CALL QTXTC(4,'DB',2)

J1=1

CALL QTABL(J1,NUMPNT,ANG,AMP)

CLOSE(1)
CLOSE(2)

READ(*,600) HOLDIT
600 FORMAT(A1)

WRITE(*,700)
700 FORMAT(/////////////////////////////////)
WRITE(*,75)
75 FORMAT(1X,'DO YOU WANT TO MAKE ANOTHER PLOT? Y OR N')
READ(*,600) NEXTP
IF(NEXTP.EQ.'Y'.OR. NEXTP.EQ.'y') GOTO 1000
STOP
END
PROGRAM PLTMM
IMPLICIT INTEGER*2(I-N)
DIMENSION ANG(600)
DIMENSION AMP(600)
DIMENSION ASTEP(5)
DIMENSION XPLT(361,7)
CHARACTER*1 Z,HOLDIT,NEXTP

OPEN(2,FILE='PRN')

WRITE(*,70)
70 FORMAT(1X,'THE PATTERN IS READY TO BE PLOTTED'//)

INPUT THE TYPE OF POLARIZATION COMPONENT DESIRED

1000 WRITE(*,100)
100 FORMAT(1X,'ENTER POLARIZATION COMPONENT DESIRED: '/5X,'1  -  E-THETA'/5X,'2  -  E-PHI'/)
READ(*,*) IPOL

ASSOCIATE DATA COLUMNS WITH POLARIZATION DESIGNATIONS

IF(IPOL.EQ.1) KPOL=2
IF(IPOL.EQ.2) KPOL=4

JCL1=68
JCL2=566
JROW1=30
JROW2=150

MINOR=1
LABEL=1
NDEC=0
ILOPT=0

READ DATA FROM FILE PLOT.DAT TO ARRAY XPLT

NUMPNT=0
OPEN(UNIT=1,FILE='PLOT.DAT',STATUS='OLD')
DO 150 I=1,361
READ(1,120,END=200) JANG,XPLT(I,2),XPLT(I,3),XPLT(I,4),XPLT(I,5)
120 FORMAT(I4,3(1X,F5.1,1X,F6.1))
XPLT(I,1)=REAL(JANG)

COUNT POINTS AS READING PROCEEDS
NUMPNT=NUMPNT+1

150 CONTINUE
200 CONTINUE

SET MINIMUM AND MAXIMUM VALUES OF ANGLE

AFST=XPLT(1,1)
ALST=(XPLT(3,1)-XPLT(2,1))*REAL(NUMPNT-1)+XPLT(1,1)
NCUT=1
TRANSFER DATA FROM XPLT ARRAY TO ANG AND AMP ARRAYS

ANG(0) = 0.0

DO 80 I = 1, NUMPNT
   ANG(I) = XPLT(I, 1)
   IF(ANG(I) .LT. ANG(I - 1)) THEN
      ANG(I) = ANG(I - 1) + ADIF
   ENDIF
   AMP(I) = XPLT(I, KPOL)
80 CONTINUE

IF(AMP(I) .LT. -50.) AMP(I) = -50.

FIND AMPMIN AND AMPMAX VALUES -

AMPMIN = -10.
AMPMAX = 10.

DO 20 I = 1, NUMPNT
   IF(AMP(I) .GT. AMPMAX) AMPMAX = AMP(I)
   IF(AMP(I) .LT. AMPMIN) AMPMIN = AMP(I)
20 CONTINUE

ASPECT = (ALST - AFST) / (AMPMAX - AMPMIN)

ROUND OFF AMPMIN & AMPMAX VALUES -

AMPMIN = INT(AMPMIN)
AMPMAX = INT(AMPMAX)

DETERMINE BEST ANGLE AND AMPLITUDE INCREMENTS TO USE -

XINC = (ALST - AFST) / 10.
YINC = (AMPMAX - AMPMIN) / 10.

ASTEP(1) = 1.
ASTEP(2) = 2.
ASTEP(3) = 5.
ASTEP(4) = 10.
ASTEP(5) = 30.

DO 30 I = 1, 5
   XSTEP = ASTEP(I)
   IF(XSTEP .GT. XINC) GOTO 40
30 CONTINUE
40 XMAJOR = XSTEP

DO 50 I = 1, 4
   YSTEP = ASTEP(I)
   IF(YSTEP .GT. YINC) GOTO 55
50 CONTINUE
55 YMAJOR = YSTEP
ISTEP = INT(YSTEP)
NSTEP=AMPMIN/ISTEP
IF(AMPMIN.LT.-50.) GOTO 58
AMPMIN=NSTEP*ISTEP-ISTEP
GOTO 350
58 AMPMIN=NSTEP*ISTEP

350 CALL QSETUP(0,3,-2,0)

60 CALL QPLOT(JCL1,JCL2,JROW1,JROW2,AFST,ALST,AMPMIN,AMPMAX,AFST,AMPMAX,AFST,AMPMAX)
1IN,IOPT,1.,ASPECT)
CALL QSMODE(6)

YMAX=AMPMAX+0.1*(AMPMAX-AMPMIN)
CALL QXAXIS(AFST,ALST,XMAJOR,MINOR,LABEL,NDEC)
CALL QYAXIS(AMPMIN,YMAX,YMAJOR,MINOR,LABEL,NDEC)
300 CALL QPTXTA(14,'ANGLE, DEGREES',2)
400 CALL QPTXTC(4,'DB',2)

J1=1

CALL QTABL(J1,NUMPNT,ANG,AMP)

CLOSE(1)
CLOSE(2)

READ(*,600) HOLDIT
600 FORMAT(A1)

WRITE(*,700)
700 FORMAT(//'DO YOU WANT TO MAKE ANOTHER PLOT? Y OR N'
WRITE(*,75)
75 FORMAT(1X,'DO YOU WANT TO MAKE ANOTHER PLOT? Y OR N')
READ(*,600) NEXTP
IF(NEXTP.EQ.'Y') GOTO 1000
END