Automatic Directivity Index Calculation Program

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# Automatic Directivity Index Calculation Program

A computer program was written for the HP 9845 and the HP 9816 to calculate the directivity index directly from the beam pattern. A graphics tablet and stylus is used to digitize data points used to compute the directivity index. Graphical output is produced on a printer and plotter.

### Subject Terms
- directivity index

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## Supplementary Notes

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## Abstract

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ABSTRACT

A computer program was written for the HP 9845 and the HP 9816 to calculate the directivity index directly from the beam pattern. A graphics tablet and stylus is used to digitize data points used to compute the directivity index. Graphical output is produced on a printer and plotter.
INTRODUCTION

This program was developed to enable the user to digitally input beam pattern data points into a computer and calculate the directivity index from this data. It eliminates the slow and monotonous task of visually determining the polar coordinates of the data points and manually keying them into the computer for processing.

Prior to the creation of this program, two methods were used to find the directivity index of a beam pattern. The first method involved extracting data from the beam pattern by reading a data point at specific, regular intervals. This method was slow and less accurate due to the fact that the operator introduced error when approximating the position of the data points. The second method required the beam pattern, which was plotted in a polar coordinate system, to be re-plotted in a rectangular coordinate system. This operation was performed by the user. Once this conversion had been completed, a mechanical device called a planimeter was used to calculate the directivity index. Obviously, this method was extremely slow. Therefore, this program greatly reduces the time and effort required to calculate the directivity index of a beam pattern. It also produces a more accurate result.

The program requires an HP 9845 computer, an HP 9111A graphics tablet and an HP 9872A plotter. In addition, it requires that the Structured Programming ROM be resident in the HP 9845 computer. Without it, certain BASIC statements cannot be executed.

A slightly modified version of this program is available for the HP 9816 computer. It provides the same capabilities as the HP 9845 version but utilizes an HP 7470 plotter instead of an HP 9872A plotter. The HP 9816 version also requires that the BASIC extensions version 2.1 be present.
DESCRIPTION OF PROGRAM

The "CALCDI" program is responsible for converting a polar plot representing a beam pattern data into a finite number of polar coordinate data points. It is from these data points that the directivity index is computed.

The program is divided into subprograms which perform the functions of initializing the graphics tablet, digitizing a directivity pattern, calculating the directivity index, and producing a hard copy output. Subprograms are also employed to perform conversions between rectangular and polar coordinate systems and perform functions not found in HP BASIC. These programming techniques result in a program that is easy to understand and modify. Subprogram modules can also be used to create new programs.

PROBLEM DEFINITION AND SOLUTION

As stated in the introduction, this program's purpose is to allow the operator to digitize a finite number of data points from a directional response pattern. The number of data points collected is dependent upon the incremental angle specified by the operator. After collecting the data, the beam pattern's directivity index calculation is performed and the result is displayed. The beam pattern is plotted on the CRT to allow the operator to verify that no errors have occurred during the data entry process.

Looking at the program from an overall view, it can be divided into 3 distinct steps. The first step involves digitizing a beam pattern using the graphics tablet. This requires converting the rectangular coordinates from the graphics tablet to the polar coordinates required by the directivity index formula. The second step is to use the polar coordinate data points to compute the directivity index. This entails changing the formula for calculating the directivity index into a procedure able to be executed by the computer. The directivity index formula, an integral, is translated into a summation. Since the original rectangular coordinate data points are not saved, the polar coordinate data points must be converted back to the rectangular system to enable them to be displayed on the CRT, printer or plotter.

STEP 1

DIGITIZING A DIRECTIONAL RESPONSE PATTERN

A beam, or directional response, pattern is digitized by placing it on the surface of the graphics tablet and tracing it with the stylus. Although the beam pattern is printed on polar coordinate paper, X and Y coordinates are entered into the computer as the digitizing process occurs. These X and Y coordinates must be converted to polar form for use by the directivity index formula.

Polar coordinate points are in the form (Rho, Theta) with Rho equalling the distance from the origin and Theta equalling an angle in the range 0-360 degrees. Rho and Theta must be derived from the X and Y coordinates. This conversion process is accomplished by the following subprograms: "Displacement," "Calclateradius," "Calcacrtangent," "Determinequad," and Convertto360." Each of these subprograms is well commented. The procedure for the conversion is also presented in algorithmic form.
STEP 2
CALCULATE THE DIRECTIVITY INDEX

The directivity index calculation is the most important segment of the program. From the polar coordinate data, we are able to determine the directivity index. This computation is performed by the subprogram called "Calcdirindex."

The directivity index is equal to ten times the common logarithm of the directivity factor. The directivity factor is defined as the ratio of the intensity in a reference direction, usually the axis, to the intensity average over all directions.

The directivity factor is calculated using the formula as presented by Bobber in Underwater Electroacoustic Measurements (Washington D.C., NRL, 1970, p. 84)

From Bobber,

\[ \text{directivity factor} = \frac{2}{\Delta \theta \cdot \sum_{i=0}^{n} A_i} \]  \hspace{1cm} (1)

where \( \Delta \theta \) equals the degrees resolution per angular interval, \( n \) equals the number of sampling points per 180 degrees, and

\[ A_i = \left( \frac{p(\theta_i)}{p_0} \right)^2 \cdot \sin \theta_i \]  \hspace{1cm} (2)

In equation 2, \( \theta_i \) is the angular measure in degrees of the polar coordinate data point. Also,

\[ \left( \frac{p(\theta_i)}{p_0} \right)^2 = 10^{-\text{db down}/10} \]  \hspace{1cm} (3)

where db down equals the difference of the maximum response axis and the radius of the polar coordinate data point. The formula for sampling the directivity pattern through 360 degrees becomes,

\[ \text{directivity factor} = \frac{4}{\Delta \theta \cdot \sum_{i=0}^{2n} A_i} \]  \hspace{1cm} (4)
Consider the case of $\Delta \theta = 5$ degrees, the default value for the resolution in "Calcdirindex." Converting $\Delta \theta$ to radians,

$$\text{directivity factor} = \frac{4}{\Delta \theta \cdot \frac{\pi}{180} \sum_{i=0}^{72} |A_i|}$$

(Simplifying,

$$\text{directivity factor} = \frac{229.2}{\Delta \theta \cdot \sum_{i=0}^{72} |A_i|}$$

The directivity factor formula of Equation 6 is transformed into a sequence of BASIC statements. "Calcdirindex" simulates the summation process by utilizing an iterative loop. The variable "resolution" corresponds to $\Delta \theta$ and 229.2 is a numeric constant.

If a directivity pattern has symmetry about the equator of the measuring sphere, then it is only necessary to use one half of the pattern in the computation. However, some patterns are nearly rotationally symmetric, but not exactly. For these "near symmetric patterns," it is desirable to average the two directivity factors as calculated for the two halves of the pattern. Therefore, it must be noted that this program assumes all beam patterns are nearly rotationally symmetric and thus performs the summation over the full 360 degrees.

STEP 3

DISPLAY THE DIRECTIVITY PATTERN ON THE OUTPUT DEVICE

The polar coordinate data is converted to $X$ and $Y$ coordinates so that it may be output to the CRT, printer, and plotter. This is accomplished by the subprograms called "Displaypattern," "Printcopy," and "Plotcopy."
Pseudo-code

Main Program

1. Clear the CRT
   a. Clear the alphanumeric raster
   b. Clear the graphics raster
2. Print Identifying message
3. Wait for person to read message
   a. Continue when operator hits "Continue" key
4. Digitize the directivity pattern using the 9111A Graphics Tablet
5. Calculate the directivity index from the polar coordinate values entered
   from the graphics tablet
6. Draw the directivity pattern on the CRT and print the directivity index
7. Output directivity pattern to printer with option of suppressing output
8. Output directivity pattern to plotter with option of suppressing output
9. Clear the CRT
   a. Clear the alphanumeric raster
   b. Clear graphics raster
10. See if operator has more directivity patterns to digitize
    
    If choice = yes then
      Repeat procedure from step 4
    Else
      End of program
    End if
MAIN PROGRAM
FLOW CHART

CLEAR THE ALPHA RASTER

CLEAR THE GRAPHICS RASTER

PRINT MESSAGE STATEING PROGRAM'S PURPOSE

DIGITIZE THE DIRECTIVITY PATTERN USING THE GRAPHICS TABLET

CALCULATE THE DIRECTIVITY INDEX

DRAW THE DIRECTIVITY PATTERN ON THE SCREEN

DRAW THE DIRECTIVITY PATTERN ON THE PLOTTER

CLEAR THE GRAPHICS RASTER

CLEAR THE ALPHA RASTER

ENTER ANOTHER DIRECTIVITY PATTERN?

YES

CLEAR THE SCREEN

NO

END
Pseudo Code

Algorithm to Convert from the Rectangular to the Polar Coordinate System

1. Input the X and Y coordinates
2. Determine its X and Y displacements from the origin in user units
3. Calculate Rho (Radius) using the X and Y displacements with Rho being measured in user units
4. Compute the principle angle given the X and Y displacements from the origin
5. Determine which quadrant the point lies in based upon its relative position to the origin
6. Given the principle angle and the quadrant, produce an angle in the range 0-360 degrees
VARIABLES

originx - the x-coordinate of the origin of the directivity pattern in digitizing units.

originy - the y-coordinate of the origin of the directivity pattern in digitizing units.

zerodegfsx - the x-coordinate of the point representing zero degrees full scale on the directivity pattern. It is measured in digitizing units.

zerodegfsy - the y-coordinate of the point representing zero degrees full scale on the directivity pattern. It is measured in digitizing units.

mrax - the x-coordinate of the point representing the maximum response axis. It is measured in digitizing units.

mray - the y-coordinate of the point representing the maximum response axis. It is measured in digitizing units.

gtabuperdb - number of digitizing units (graphic tablet units) per decibel. This is used as a scaling or conversion factor.

dbfullscale - number of decibels from the origin to zero degrees full scale.

radiusvalues (*) - an array representing the radii of the polar coordinate data points.

angle (*) - an array representing the angles of the polar coordinate data points.

mra - the maximum response axis value.

resolution - the incremental angle, which determines the number of data points gathered.

dirindex - the value of the directivity index.

skew - an offset angle to compensate for directivity patterns positioned crookedly on the graphics tablet digitizing area.
AUTOMATIC DIRECTIVITY INDEX CALCULATION PROGRAM

by JEHU ROOKARD

Created 2 AUG 1984

THIS PROGRAM DIGITIZES A DIRECTIVITY PATTERN AND CALCULATES THE DIRECTIVITY INDEX

Main:

OPTION BASE 0

COM Originx,Originy,Zerodegfsx,Zerodegfsy,Mmax,Mmaw

COM Gtabuperdb,Dbfullscale

COM Radiusvalues<360),Angle<360)

COM Mra

COM Resolution

COM Dirindex

CALL Clearscreen

PLOTTER IS 13,"GRAPHICS"

GRAPHICS

GCLEAR

PLOTTER IS OFF

PRINT "THIS PROGRAM ENTERS A DIRECTIVITY PATTERN FROM THE GRAPHICS TABLET AND CALCULATES THE DIRECTIVITY INDEX"

INPUT "PRESS 'CONT' WHEN READY TO PROCEED",Cont$

CALL Enterapattern

CALL Calcdirindex

CALL Displaypattern

CALL Printcopy

CALL Plotcopy

PLOTTER IS 13,"GRAPHICS"

CLEAR THE GRAPHICS RASTER

CALL Enterapattern

CALL Calcdirindex

CALL Displaypattern

CALL Printcopy

CALL Plotcopy

PLOTTER IS 13,"GRAPHICS"

CLEAR THE GRAPHICS RASTER

EXIT GRAPHICS

PLOTTER IS OFF

CALL Clearscreen

Yesno$="Y"

INPUT "ENTER ANOTHER PATTERN - Y/N. DEFAULT IS 'Y'",Yesno$

IF Yesno$="Y" THEN

PLOTTER IS 13,"GRAPHICS"

CLEAR THE GRAPHICS RASTER

GCLEAR

PLOTTER IS OFF

CALL Clearscreen

CALL Enterapattern

CALL Clearscreen

SUB Enterapattern

CALL Clearscreen

PLOTTER IS 7,6,"9872A"

THE 9111A GRAPHICS TABLET CAN ONLY BE ACCESSED THROUGH THE GRAPHICS ROM. ALTHOUGH IT IS A GRAPHICS TABLET, THE COMPUTER TREATS IT AS A PLOTTER

OUTPUT 706;"IN"

CALL Setupaxes

THE DIGITIZING AREA AND ALL POINTS ENTERED FROM IT
CALL Entercurve ! DIGITIZE THE ACTUAL DIRECTIVITY PATTERN
SUBEND

Setupaxes: ! ENTER THE NECESSARY SCALING VALUES FROM THE GRAPHICS TABLET SG THAT A BASIS FOR ENTERING ALL SUCCEEDING POINTS IS ESTABLISHED
! A METHOD (SCALE) FOR CONVERTING BETWEEN DIGITIZING UNITS AND USER UNITS IS SET UP

SUB Setupaxes
OPTION BASE 0
COM Originx,Originy,Zerodegfsx,Zerodegfsy,Mrax,Mray
COM Gtabuperdb,Dbfullscale
COM Radiusvalues(360),Angle(360)
COM Mra
COM Resolution
COM Dirindex
COM Skew
Dbfullscale=50
INPUT "ENTER NO. OF db'S FROM ORIGIN TO ZERO DEGREES FULL SCALE. DEFAULT IS 5",Dbfullscale
IF Dbfullscale>5 THEN
PRINT "NO VALUES GREATER THAN 50 ALLOWED. PLEASE RE-ENTER"
GOTO 850
ELSE
END IF
Resolution=5
INPUT "ENTER INCREMENTAL ANGLE. DEFAULT IS 5 DEGREES",Resolution
Resolution=INT(Resolution)
IF Resolution<1 THEN
PRINT "INCREMENTAL ANGLE MUST BE GREATER THAN OR EQUAL TO 1"
GOTO 930
ELSE
END IF
DISP "DIGITIZE ORIGIN"
OUTPUT 706;"SG"
CALL Status
OUTPUT 706;"0D"
ENTER 706;Originx,Originy
OUTPUT 706;"BP24,125,4"
SET TO SINGLE POINT MODE
WAIT UNTIL GRAPHICS TABLET IS READY
INSTRUCT GRAPHICS TABLET TO TRANSMIT POINT
GET THE POINT FROM THE GRAPHICS TABLET
INSTRUCT GRAPHICS TABLET TO BEEP
DISP "DIGITIZE ZERO DEGREE FULL SCALE"
CALL Status
OUTPUT 706;"OD"
Enter 706;Zerodegfsx,Zerodegfsy
OUTPUT 706;"BP"
DISP "DIGITIZE MAXIMUM RESPONSE AXIS"
CALL Status
OUTPUT 706;"OD"
Enter 706;Mrax,Mray
OUTPUT 706;"BP"
DISP "DIGITIZE MAXIMUM RESPONSE AXIS"

Differencex=ABS(Zerodegfsx-Originx)
Differencexy=ABS(Zerodegfsy-Originy)
CALL Calculateradius(Differencex,Differencexy,Rho_zerodegfs)
Gtabuperdb=Rho_zerodegfs/Dbfullscale

CALCULATE THE NUMBER OF DIGITIZING UNITS PER DECIBEL BY DIVIDING THE RADIUS (Rho) AT FULL SCALE BY THE NUMBER OF DECIBELS FULL SCALE
Differencex=ABS(Zerodegfsx-Originx)
Differencexy=ABS(Zerodegfsy-Originy)
CALL Calculateradius(Differencex,Differencexy,Rho_zerodegfs)
Gtabuperdb=Rho_zerodegfs/Dbfullscale

CALCULATE THE MAXIMUM RESPONSE AXIS VALUE BY DIVIDING THE VALUE FOR THE MAXIMUM RESPONSE AXIS IN DIGITIZING UNITS BY THE NUMBER OF DIGITIZING UNITS PER DECIBEL
1310 ! ( i.e. CONVERT FROM DIGITIZING UNITS TO USER UNITS )
1320 Differencex=ABS(Mrax-Originx)
1330 Differencey=ABS(Mray-Originy)
1340 CALL Calculatoradius(Differencex,Differencey,Mra)
1350 Mra=Mra/Gtabuperdb
1360 !
1370 ! DETERMINE THE "SKEW ANGLE" TO CORRECT FOR ERRORS THAT WILL RESULT FROM
1380 ! THE ORIGINAL DIRECTIVITY PATTERN BEING POSITIONED CROOKED OR SKewed ON
1390 ! THE GRAPHICS TABLET. THIS CORRECTION FACTOR ALLOWS THE USER TO PLACE THE
1400 ! ORIGINAL DIRECTIVITY PATTERN IN any POSITION inside THE GRAPHICS TABLET
1410 ! DIGITIZING AREA AND STILL GATHER ACCURATE DATA. IT ALSO RESULTS IN A
1420 ! TRUE POLAR CO-ORDINATE SYSTEM
1430 CALL Displacement(Zerodegfsx,Zerodegfsy,Xvalue,Yvalue)
1440 CALL Calcartangent(Xvalue,Yvalue,Relativeangle)
1450 CALL Determinequad(Zerodegfsx,Zerodegfsy,Quadrant)
1460 CALL Convertto360(Relativeangle,Quadrant,Absoluteangle)
1470 Skew=Absoluteangle
1480 PLOTTER 7,6 IS OFF ! DEACTIVATE GRAPHICS TABLET
1490 ! ( i.e. DON'T SEND GRAPHICS COMMANDS TO IT )
1500 SUBEND
1510 !
1520 !
1530 !
1540 Entercurve: ! ENTER A DIRECTIVITY PATTERN USING THE 9111A GRAPHICS TABLET
1550 ! THE USER MUST START DIGITIZING FROM ZERO DEGREES AND
1560 ! CONTINUE UNTIL HE REACHES 360 DEGREES. 'Resolution'
1570 ! DETERMINES THE NUMBER OF DATA POINTS ACCEPTED.
1580 ! 360/Resolution SECTORS ARE CREATED AND A DATA POINT
1590 ! IS ENTERED FOR EACH SECTOR AND STORED IN ITS RESPECTIVE
1600 ! ARRAY ELEMENT
1610 SUB Entercurve
1620 OPTION BASE 0
1630 COM Originx,Originy,Zerodegfsx,Zerodegfsy,Mrax,Mray
1640 COM Gtabuperdb,Dbfullscale
1650 COM Radiusvalues(360),Angle(360)
1660, COM Mra
1670 COM Resolution
1680 COM Dirindex
1690 COM Skew
1700 DEG
1710 ! DEGREES MODE (NOT RADIANS)
1720 ! "ENTERCURVE" EXPECTS TO HAVE A "COMMUNICATIONS CHANNEL" WITH THE
1730 ! GRAPHICS TABLET ALREADY ESTABLISHED. IT ALSO EXPECTS THE GRAPHICS
1740 ! TABLET TO HAVE BEEN INITIALIZED. ( AS IN "SETUPAXES" )
1750 ! "ENTERCURVE WILL RE-ACTIVATE THE GRAPHICS TABLET IF IT HAS PREVIOUSLY
1760 ! BEEN DEACTIVATED
1770 !
1780 PLOTTER 7,6 IS ON
1790 OUTPUT 706;"CN" ! SET GRAPHICS TABLET TO CONTINUOUS
1800 ! SAMPLING MODE
1810 DISP "START DIGITIZING FROM ZERO DEGREES AND PROCEED COUNTER-CLOCKWISE"
1820 FOR Anglecounter=0 TO 360-Resolution STEP Resolution
1830 CALL Status ! WAIT UNTIL GRAPHICS TABLET IS READY
1840 OUTPUT 706;"OD"
1850 ENTER 706;Beamformx,Beamformy ! GET DATA POINT
1860 !
1870 ! CONVERT THE X AND Y COORDINATES TO POLAR COORDINATES BY CALLING THE
1880 ! FOLLOWING SUBPROGRAMS IN THE PROPER SEQUENCE
1890 !
1900 CALL Displacement(Beamformx,Beamformy,Xdisplacement,Ydisplacement)
1910 CALL Calcthecaliradius(Xdisplacement,Ydisplacement,Radius)
1920 CALL Calcartangent(Xdisplacement,Ydisplacement,Relativeangle)
1930 CALL Determinequad(Beamformx,Beamformy,Quadrant)
1940 CALL Convertto360(Quadrant,Relativeangle,Absoluteangle)
1950 !
1960 ! TEST TO SEE IF THE POINT LIES WITHIN THE SECTOR. IF IT DOES, THEN STORE
1970 ! IT IN ITS RESPECTIVE ARRAY ELEMENT. REMEMBER TO CORRECT FOR ANY "SKEW"
1980 ! ERRORS THAT MAY EXIST
1990 !
2000 IF (Absoluteangle-Skew)>Anglecounter) AND (Absoluteangle-Skew<Anglecounter+
Resolution) THEN
2010 ELSE
2020 !
2030 ! IF 'Skew' IS NEGATIVE THEN PERFORM THE TEST BUT WITH 360 DEGREES ADDED
2040 ! TO MAKE THE ANGLE POSITIVE
2050 !
2060 IF (Absoluteangle+360-Skew)>Anglecounter) AND (Absoluteangle+360-Skew<Angle
counter+Resolution) THEN
2070 Absoluteangle=Absoluteangle+360
2080 ELSE
2090 GOTO 1830
2100 END IF
2110 END IF
2120 DISP "ANGLE=";Absoluteangle-Skew,"db DOWN=";Mra-Radius
2130 Radiusvalues<Anglecounter)=Radius
2140 Angle(Anglecounter)=Absoluteangle-Skew
2150 BEEP
2160 NEXT Anglecounter
2170 !
2180 PLOTTER 7,6 IS OFF ! DEACTIVATE GRAPHICS TABLET
2190 SUBEND
2200 !
2210 !
2220 !
2230 Displacement: ! GIVEN A POINT'S X AND Y CO-ORDINATES, DETERMINE IT'S
2240 ! RELATIVE X AND Y DISPLACEMENTS FROM THE ORIGIN
2250 ! 'Xvalue' IS THE X-CO-ORDINATE OF THE POINT IN GRAPHIC
2260 ! TABLET UNITS.
2270 ! 'Yvalue' IS THE Y-CO-ORDINATE OF THE POINT IN GRAPHIC
2280 ! TABLET UNITS
2290 ! 'Xdisplacement' IS THE RELATIVE X-DISPLACEMENT FROM THE
2300 ! ORIGIN IN USER DEFINED UNITS
2310 ! 'Ydisplacement' IS THE RELATIVE Y-DISPLACEMENT FROM THE
2320 ! ORIGIN IN USER DEFINED UNITS
2330 SUB Displacement<Xvalue,Yvalue,Xdisplacement,Ydisplacement>
2340 COM Originx,Originy,Zerodegsx,Zerodegsy,Mrax,Mray
2350 COM Gtabuperdb,Dbfulfyscale
2360 Xdisplacement=(Xvalue-Originx)/Gtabuperdb
2370 Ydisplacement=(Yvalue-Originy)/Gtabuperdb
2380 SUBEND
2390 !
2400 !
2410 !
2420 Calculatoradius: ! CALCULATE THE RADIUS USING THE PYTHAGOREAN THEOREM
2430 ! (DISTANCE FORMULA)
2440 SUB Calculatoradius<X,Y,R>
2450 R=SQR(X^2+Y^2)
2460 SUBEND
2470 !
2480 !
2490 !
2500 Calcarctangent: ! CALCULATE THE VALUE OF THE ARCTANGENT GIVEN 'X' AND 'Y'
2510 ! ALSO RESOLVE ANY INVALID INPUT PARAMETERS TO THE
2520 ! ARCTANGENT FUNCTION BY SUBSTITUTING THE CORRECT VALUE
2530 SUB Calcarctangent<X,Y,Angle>
2540 DEG ! DEGREES MODE (NOT RADIANS)
2550 ON ERROR GOTO Recovery
2560 Angle=ATN(Y/X)
2570 SUBEXIT
2580 Recovery: ! ROUTINE TO RECOVER INVALID INPUT PARAMETERS TO
2590 ! ARCTANGENT FUNCTION. (ie. DENOMINATOR CAN'T EQUAL
2600 ! ZERO)
! \text{ANGLE} = \text{ATN}(Y/X); \text{ASSUMES} \text{X} \text{DOES NOT} 0

IF \text{ERRN} = 31 \text{THEN} ! \text{IF DIVISION BY ZERO ERROR THEN CORRECT THE ERROR}
! \text{BY ASSIGNING THE CORRECT VALUE OR SOME ARBITRARY}
SELECT \text{SGN}(Y) ! \text{A NUMBER IS EITHER +, -, OR ZERO, SO DETERMINE THE}
! \text{CORRECT VALUE FOR THE 3 CASES OF 'Y'}
CASE 1 ! IF 'Y' IS POSITIVE THEN THE CORRECT ANSWER IS 90 DEGREES
! (> \text{THE POINT LIES SOMEWHERE ON THE Y-AXIS, BUT ABOVE}
! \text{THE X-AXIS})
\text{Angle} = 0 ! 0 \text{PRODUCES A VALUE OF 90 DEGREES AFTER BEING PROCESSED}
! BY "CONVERTTO360"
CASE 0 ! IF 'Y' IS ZERO THEN THE POINT IS AT THE ORIGIN, SO
! \text{ARBITRARILY ASSIGN AN ANGLE OF ZERO DEGREES, THE VALUE}
\text{Angle} = 451 ! 451 \text{PRODUCES A VERY LARGE VALUE AFTER BEING PROCESSED BY}
! "CONVERTTO360". \text{THIS RESULTS IN "ENTERCURVE" REJECTING}
\text{Angle} = 0 ! \text{ANY POINTS THAT LIE AT THE ORIGIN BECAUSE THEY WILL BE}
! \text{OUT OF RANGE}
CASE -1 ! IF 'Y' IS NEGATIVE THEN THE CORRECT ANSWER IS 270 DEGREES
! (! \text{THE POINT LIES SOMEWHERE ON THE Y-AXIS, BUT BELOW THE}
\text{X-AXIS})
\text{Angle} = 0 ! 0 \text{PRODUCES A VALUE OF 270 DEGREES AFTER BEING PROCESSED}
! BY "CONVERTTO360"
END SELECT ! \text{NO NEED FOR A 'CASE ELSE' STATEMENT AS A NUMBER IF EITHER}
! 0, +- OR ZERO
SUBEXIT ! END OF ERROR HANDLER ROUTINE
ELSE ! IF THIS ISN'T A DIVISION BY ZERO ERROR, THEN DISPLAY THE
! \text{ERROR MESSAGE AND PAUSE PROGRAM EXECUTION}
DISP \text{ERRM}$
PAUSE
END IF
SUBEND

Determinequad: ! \text{DETERMINE WHICH QUADRANT THE POINT LIES IN BASED UPON}
! WHETHER THE POINT LIES TO THE LEFT OR RIGHT OF THE
! Y-AXIS AND ABOVE OR BELOW THE X-AXIS
SUB Determinequad(Xvalue,Yvalue,Quadrant)
COM Originx,Originy,Zerodegfx,Zerodegfy,Mrax,Mray
IF Xvalue > Originx THEN ! IN QUADRANT 1 OR 4 THEN
IF Yvalue > Originy THEN ! IN QUADRANT 1
Quadrant = 1
ELSE
Quadrant = 4
END IF
ELSE
Quadrant = 4
END IF
ELSE
IF Yvalue > Originy THEN ! IN QUADRANT 2 OR 3 OR ON Y-AXIS THEN
Quadrant = 2
ELSE
Quadrant = 3
END IF
ELSE
Quadrant = 4
END IF
ELSE
Quadrant = 3
ELSE
Quadrant = 4
END IF
END IF
SUBEND

Convertto360: ! \text{GIVEN THE PRINCIPAL ANGLE AND THE QUADRANT PRODUCE}
! \text{AN ANGULAR VALUE IN THE RANGE 0 TO 360 DEGREES}
! 'Relativeangle' IS THE PRINCIPAL ANGLE
! 'Quadrant' IS IN THE RANGE 1-4 (< FROM CARTESIAN
CO-ORDINATE SYSTEM

'Absoluteangle' IS THE RESULTANT ANGULAR VALUE IN THE RANGE 0-360 DEGREES

SUB Convertto360(Relativeangle, Quadrant, Absoluteangle)

SELECT Quadrant

CASE 1 ! FIRST QUADRANT
  0 <= Relativeangle < 90
  Absoluteangle = Relativeangle + 270
CASE 2 ! SECOND QUADRANT
  90 <= Relativeangle < 180
  Absoluteangle = Relativeangle + 90
CASE 3 ! THIRD QUADRANT
  180 <= Relativeangle < 270
  Absoluteangle = Relativeangle + 90
CASE 4 ! FOURTH QUADRANT
  270 <= Relativeangle < 360
  Absoluteangle = Relativeangle + 270
END SELECT

SUBEND

Clearscreen: ! CLEAR THE ALPHA RASTER BY PRINTING 24 BLANK LINES

SUB Clearscreen
FOR Line = 1 TO 24
PRINT
NEXT Line
SUBEND

Displaypattern: ! DRAW THE DIRECTIVITY PATTERN ON THE GRAPHICS RASTER AND LABEL THE DIRECTIVITY INDEX

SUB Displaypattern
OPTION BASE 0
COM Originx, Originy, Zerodegfsx, Zerodegfsy, Mrax, Mray
COM Gtabuperdb, Dbfullscale
COM Radiusvalues(360), Angle<360>
COM Mra
COM Resolution
COM Dirindex
DEG
PLOTTER IS 13,"GRAPHICS" ! DEGREES MODE ( NOT RADIANS )
GRAPHICS ! ACTIVATE THE CRT GRAPHICS RASTER
FRAME 10, 10, 0, 0, 1, 1
FOR Anglecounter = 0 TO 360 - Resolution STEP Resolution
X = Radiusvalues(Anglecounter) * COS(Angle(Anglecounter) + 90)
Y = Radiusvalues(Anglecounter) * SIN(Angle(Anglecounter) + 90)
IF Anglecounter = 0 THEN
MOVE X, Y
ELSE
DRAW X, Y
END IF
NEXT Anglecounter
MOVE 37, 2
CSIZE 3.2
LABEL "Directivity index ="; DROUND(Dirindex, 6)
SCALE -Dbfullscale*.75, Dbfullscale*.75, -Dbfullscale, Dbfullscale
FRAME
AXES 10, 10, 0, 0, 1, 1
FOR Anglecounter = 0 TO 360 - Resolution STEP Resolution
X = Radiusvalues(Anglecounter) * COS(Angle(Anglecounter) + 90)
Y = Radiusvalues(Anglecounter) * SIN(Angle(Anglecounter) + 90)
IF Anglecounter = 0 THEN
MOVE X, Y
ELSE
DRAW X, Y
END IF
NEXT Anglecounter
PLOTTER IS OFF ! DEACTIVATE THE CRT GRAPHICS RASTER
SUBEND

Calcdirindex: ! CALCULATE THE DIRECTIVITY INDEX GIVEN THE RADIUS (Rho)
! AND THE ANGLE (0-360 DEGREES)

3930 SUB Calcdirindex
3940 OPTION BASE 0
3950 COM Originx,Originy,ZeroDegFx,ZeroDegFs,Mra,Mray
3960 COM Gtabuperdb,Dbfullscale
3970 COM Radiusvalues(360),Angle(360)
3980 COM Mra
3990 COM Resolution
4000 COM Dirindex
4010 FOR Anglecounter=0 TO 360-Resolution STEP Resolution
4020 Temp=ABS(SIN(Angle(Anglecounter)))*10^(-<Mra-Radiusvalues(Anglecounter)>)/10
4030 Sum=Temp+Sum
4040 NEXT Anglecounter
4050 Dirfactor=229.2/(Resolution*Sum)
4060 Dirindex=10*LGT(Dirfactor)
4070 SUBEHD
4080 ! PRINTCOPY:
4090 Yesno$="N"
4100 INPUT "DUMP DIRECTIVITY PATTERN TO PRINTER - Y/N. DEFAULT IS 'N'",Yesno$
4110 IF Yesno$="Y" THEN
4120 PLOTTER 13 IS ON
4130 PRINTER IS 0
4140 DUMP GRAPHICS
4150 PRINT CHR$(12) ! ADVANCE TO TOP OF NEXT SHEET OF PAPER
4160 PRINTER IS 16
4170 PLOTTER 13 IS OFF
4180 ELSE
4190 END IF
4200 SUBEND
4210 Plotcopy:
4220 INPUT "DUMP DIRECTIVITY PATTERN TO PLOTTER - Y/N. DEFAULT IS 'N'",Yesno$
4230 IF Yesno$="Y" THEN
4240 PLOT THE DIRECTIVITY PATTERN ON THE PLOTTER AND LABEL THE
4250 DIRECTIVITY INDEX
4260 OPTION BASE 0
4270 COM Originx,Originy,ZeroDegFx,ZeroDegFs,Mra,Mray
4280 COM Gtabuperdb,Dbfullscale
4290 COM Radiusvalues(360),Angle(360)
4300 COM Mra
4310 COM Resolution
4320 COM Dirindex
4330 FOR Anglecounter=0 TO 360-Resolution STEP Resolution
4340 Temp=ABS(SIN(Angle(Anglecounter)))*10^(-<Mra-Radiusvalues(Anglecounter)>)/10
4350 Sum=Temp+Sum
4360 NEXT Anglecounter
4370 Dirfactor=229.2/(Resolution*Sum)
4380 Dirindex=10*LGT(Dirfactor)
4390 SUBEHD
4400 ! Status:
4410 IF Bit(S,2)=0 THEN 4380
4420 END IF
4430 SUBEND
4440 Plotcopy:
4450 INPUT "DUMP DIRECTIVITY PATTERN TO PLOTTER - Y/N. DEFAULT IS 'N'",Yesno$
IF Yesno$="Y" THEN
4630 IF Dimflag=1 THEN 4630
4630 DIM Temp$(2)"[35]
4640 Dimflag=1
4650 PLOTTER IS 7,5,"9872A"
4660 Temp$(0)=" "
4670 Temp$(1)=" "
4680 Temp$(2)=" "
4690 INPUT "ENTER LABEL FOR FIRST LINE",Temp$(0)
4700 INPUT "ENTER LABEL FOR SECOND LINE",Temp$(1)
4710 INPUT "ENTER DATE (OPTIONAL)",Temp$(2)
4720 LOCATE 0,RATIO*100,0,100
4730 FRAME
4740 LORG 2
4750 LDIR 90
4760 CSIZE 2.6
4770 MOVE 120,4 ! DRAW LABEL 1
4780 LABEL Temp$(0) ! DRAW LABEL 2
4790 MOVE 125,4 ! DRAW LABEL 3
4800 LABEL Temp$(1)
4810 MOVE 130,4 ! DRAW LABEL DIRECTIVITY INDEX
4820 LABEL "Directivity index =",DROUND<Dirindex,6)
4830 LDIR 0
4840 ! SCALE PLOTTING AREA TO USER DEFINED UNITS
4850 SCALE -Dbfullscale,Dbfullscale,-Dbfullscale*.75,Dbfullscale*.75
4860 ! DRAW AXES WITH TICK MARKS EVERY 10 db
4870 AXES 10,10,0,0,1,1
4880 ! DRAW DIRECTIVITY PATTERN
4890 FOR Anglecounter=0 TO 360-Resolution STEP Resolution
4900 X=Radiusvalues(Anglecounter)*COS(Angle(Anglecounter)+180)
4910 IF Anglecounter=0 THEN
4920 END IF
4930 NEXT Anglecounter
4940 DRAW X,Y
4950 ELSE
4960 DRAW X,Y
4970 END IF
4980 FOR Anglecounter=0 TO 360-Resolution STEP Resolution
4990 X=Radiusvalues(Anglecounter)*COS(Angle(Anglecounter)+180)
5000 PEN 0
5010 Yesno$="N"
5020 INPUT "MAKE ANOTHER PLOT - Y/N. DEFAULT IS <N>0",Yesno$
USING THE PROGRAM

This program is very easy to use. Most input responses require simple "yes" or "no" answers. The process of digitizing a directivity pattern consumes the most time, and this process uses the stylus of the graphics tablet for input. To execute the program, the operator must complete the following simple steps:

1. Turn on the HP 9845 computer
2. Turn on the HP 9872A plotter
3. Turn on the HP 9111A graphics tablet
4. Load "CALCDI" from the proper mass storage device
5. Press the "RUN" key
6. Respond accordingly to computer generated questions
Sample circle pattern

Directivity index = -0.0435673
Sample wedge pattern generated from previous page.
Sample spike pattern generated from previous page
Original Pattern

DI = 18.419

Scale: 1dB per small radial division

Polar Pattern

Transmitting & Receiving

Transducer: 

Frequency: (kHz)

Test Dist.:

Depth:

Date:

DI = 18.419

Fig. Of
Sample of typical pattern generated from previous page using 5° resolution
Sample of typical pattern generated from previous page using 2° resolution