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Dataplot 70: Fortran-Callable Plotting Routines

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.
[2] Part of the Center for Radiation Research.
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Carol V. Young and
Philip G. Stein

Institute for Basic Standards
U.S. National Bureau of Standards
Washington, D.C. 20234

U.S. DEPARTMENT OF COMMERCE, Frederick B. Dent, *Secretary*
NATIONAL BUREAU OF STANDARDS, Richard W. Roberts, *Director*

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DATAPLOT 70:
FORTRAN-CALLABLE PLOTTING ROUTINES

by

Carol V. Young
and
Philip G. Stein

Office of Measurement Services
Institute for Basic Standards
National Bureau of Standards

A description is given of Dataplot 70, a program which enables plotting (1) lines between pairs of X-Y coordinates, and (2) a string of ASCII characters at a given X-Y coordinate on the electrostatic printer/plotter. Detailed instructions are provided enabling the user to (1) convert data to plotter format, (2) draw axis, (3) label axis, (4) scale data, (5) handle arrays, (6) produce symbols at end points, and (7) offset the origin. Hardware and software requirements as well as loading and operating instructions are given.

A sample FORTRAN calling program is included and each instruction is explained in detail. The output of the calling program is shown. Error messages produced by Dataplot 70 are explained.

Key Words: Digital plotter; graph; graphics; minicomputer; plotter

1. INTRODUCTION

1.1 General

The Dataplot 70 package enables plotting of (1) lines between pairs of X-Y coordinates and (2) a string of ASCII characters at a given X-Y coordinate, on an electrostatic printer/plotter. Provisions are made to draw and label axes, scale data, handle arrays (sets of X,Y locations of data points), produce symbols at end-points and offset the origin.

The package consists of two parts: (1) a special run-time library for data formatting made up of 5 FORTRAN and 6 ASSEMBLER subroutines, and (2) a load module containing the assembler language plotter and driving routines.

The user writes a FORTRAN program to call the data formatting subroutines. These convert his floating point data coordinates and ASCII labels and titles to properly formatted data for input to the plotter routines. This formatted data is output to a mass storage device.

The plotter routines will read this file from the mass storage device, sort and process the data, and produce a plot on the electrostatic printer/plotter.

Paper tape punch and reader can be substituted for the mass-storage device.

Files to be input directly into the plotter can be prepared on other computers but must be in the proper format (see Section 3.2). The plotter is capable of accepting files which are unsorted, or are sorted in either ascending or descending order.

1.2 Hardware Requirements

The hardware required to support the Dataplot 70 consists of:

A. Any one of Interdata models 5, 70, 80, 85, 74, 7/16, 7/32 with high speed ALU of software supports for floating point.

B. 8 KB of core (minimum)

C. Some binary data storage peripheral device (paper tape reader and punch, disc, tape, or cassette)

D. Operators console to print error messages

E. Varian Statos 31 plotter with Varian interface to Interdata I/O multiplexor bus

1.3 Software Requirements

BOSS or other Interdata operating system, modified to allow user direct I/O as described in section 3.5 is required to support the Dataplot 70 package. The package is not designed for use in a real-time environment.

1.4 Axis of Plot

The origin of the plot is in the lower left-hand corner of the plot area. The X direction is in the direction of the paper movement. The Y direction is across the width of the paper. See Figure 1.4.

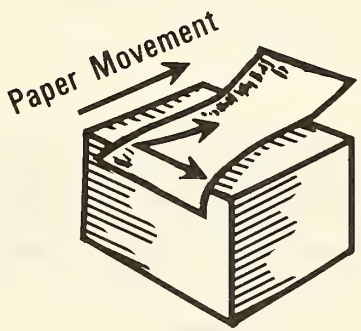


FIGURE 1.4.

A plotter unit of X corresponds to one step (0.01") of paper movement in the printer. A plotter unit of Y corresponds to 0.01" across the page and represents the smallest stylus interval.

2. DATA FORMATTING

2.1 General

A user's FORTRAN program first reads in or generates data to be plotted. Next, it calls the data formatting subroutines. These process the user's data producing data in the proper format for input to the plotter routines. The first call must be "CALL OPEN" and the last call must be "CALL CLOSE."

Each set of formatted data (vector or character) produced by the data formatting subroutines requires 8 bytes (see Section 3.2). The subroutines use a 512 byte buffer which holds 64 sets of formatted data. The subroutines process 64 sets of data and then output the entire buffer as one record to a mass storage device. This is repeated until all the data has been processed and output.

2.2 Data Format

All X and Y coordinate data are input to the data formatting subroutines as single precision floating point numbers representing displacement (in inches) from the origin. The subroutines output the data to a mass storage device as positive integers (15 bits) in plotter units (100 plotter units/inch).

2.3 Range of Data

The value of the X coordinate must be positive. The value of the Y coordinate must be positive and less than 14.08 inches. If any of the floating point coordinate data are outside these ranges, then either the data must be scaled, (see Section 2.4.8) the origin offset, (see Section 2.4.2) or both.

2.4 Data Formatting Subroutines

2.4.1 OPEN

Subroutine OPEN initializes pointers and rewinds the mass storage device.

Calling Sequence: CALL OPEN

2.4.2 ORIG

ORIG offsets the origin.

Calling Sequence: CALL ORIG (X,Y)

Where:

X Is the distance (in inches) along the X axis by which the new (relative) origin will be offset from the old. (Floating point)

Y Is the distance (in inches) along the y axis by which the new (relative) origin will be offset from the old. (Floating point)

Each coordinate processed by the data formatting subroutine after this call will be relative to the new origin.

2.4.3 VECT

VECT generates the vector end point data which, when input to the plotter routines will draw a line between the given pairs of X-Y coordinates.

Calling Sequence: CALL VECT (X1, Y1, X2, Y2)

Where X1, Y1, X2, Y2 are single precision floating pointing numbers representing inches of displacement from the origin.

Provision is made for plotting a continuous series of points. The second X-Y coordinate from the most recent VECT call are saved as continuation points. If in a VECT call X1 = 999. and Y1 = 999., the current continuation points are used as X1 and Y1. The initial continuation point can be set by the subroutine CURR (see Section 2.4.4).

2.4.4 CURR

CURR initializes the beginning point when plotting a continuous series of points (see VECT above).

Calling Sequence: CALL CURR (X,Y)

Where X and Y are single precision floating point numbers representing distance in inches from the origin.

Example:

```
CALL CURR (X(1),Y(1))
DO 10 I = 2,N
10 CALL VECT (999., 999., X(I),Y(I))
```

2.4.5 CHAR

The subroutine CHAR generates the code which when input to the plotter writes the ASCII string starting at the given X-Y coordinate. The characters are software generated dot matrix characters in two sizes: small (0.05" x 0.07") and large (0.10" x 0.14") and two orientations: Upright (0 degrees rotated from the Y axis) and sideways (-90 degrees rotated from the Y axis). The standard spacing for small characters is 0.03 inches and for large characters is 0.04 inches.

Calling Sequence: CALL CHAR (X, Y, STRING, ISAOR, NCHAR, ISPAC)

Parameters:

X, Y — X and Y coordinates (in inches) of the first letter (upper left-hand corner of an upright character, lower left-hand corner of a sideways character). (Floating point)

STRING — Address of the first word containing the ASCII character string to be plotted. It can be given as a variable name, or as per the example below.

ISAOR — Size and orientation:

0 = small, 0 degrees rotation from Y direction
1 = small, -90 degrees rotation from Y direction
2 = large, 0 degrees rotation from Y direction
3 = large, -90 degrees rotation from Y direction
(Integer)

NCHAR — The total number of characters to be plotted in the string. (Integer)

ISPAC — Spacing constant in styli or scans from the starting coordinate of the previous character.

A negative number causes default standard spacing. (Integer)

Example: CALL CHAR (1.0, 1.0, 6HSTATOS, 2,6, -1)

2.4.6 SYMBOL

SYMBOL generates code which, when input to the plotter routines will produce a symbol centered at the given X-Y coordinate.

Calling Sequence: CALL SYMBOL (X, Y, IEQ)

X, Y Single precision floating point coordinates

IEQ Positive integer designating symbol to be produced. (1, 2, 3, 4, or 5.)

The types of symbols indicated by these integers are shown in Figure 2.1.

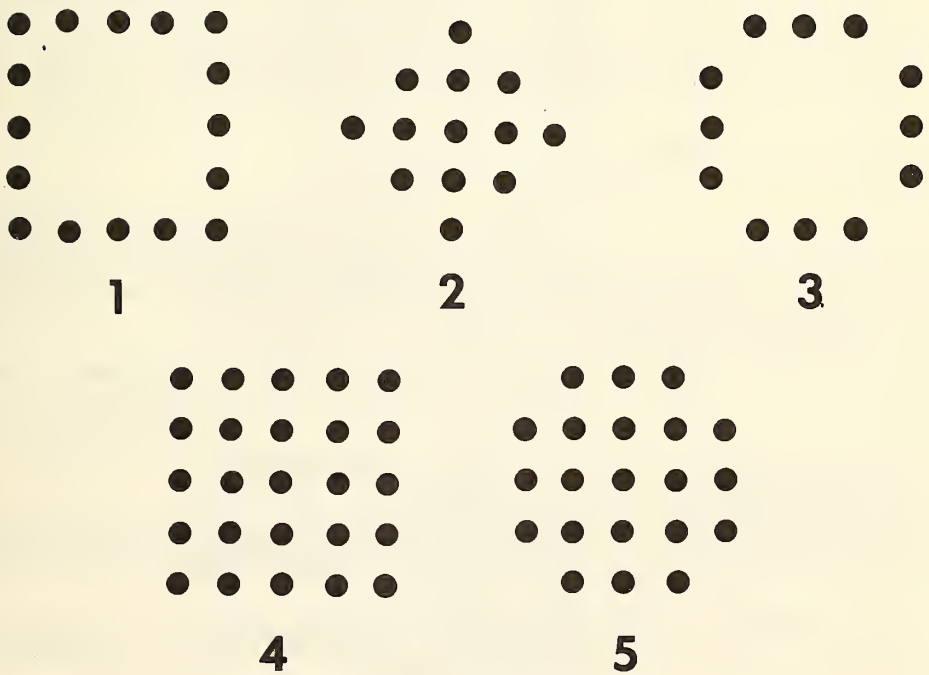


FIGURE 2.1.

2.4.7 NUMBER

NUMBER converts single precision floating point numbers to ASCII code and generates code which when input to the plotter routines will print the number starting at the given X-Y coordinate.

Calling Sequence: CALL NUMBER (X, Y, FPN, ISAOR, NDEC)

This call will plot the floating point, single precision number FPN at the point X, Y.

Parameters:

X, Y — Coordinates (in inches) of the first number in the string (upper left-hand corner of upright number, lower left-hand corner of sideways number). (Floating point)

FPN — Floating point number to be plotted. If negative, will be prefixed with a minus sign. Leading zeros will be suppressed, except the zero to the left of the decimal point. The floating point number is rounded by adding 5 to the digit to the right of the last digit to be plotted, then truncating the result. (Floating point)

ISAOR — Size and Orientation:

0 = small, 0 degrees rotation from Y direction
1 = small, -90 degrees rotation from Y direction
2 = large, 0 degrees rotation from Y direction
3 = large, -90 degrees rotation from Y direction
(Integer)

NDEC — Number of decimal places to be plotted to the right of the decimal point. (Integer)

If $0 < NDEC \leq 4$, NDEC digits will be plotted to the right of the decimal.

If NDEC = 0, only the decimal will be plotted to the right of the integer portion of the floating point number.

If NDEC = -1, the decimal point is omitted along with the fraction.

If NDEC < -1, NDEC-1 numbers are truncated from the right side of the integer portion of the floating point number. The number of characters plotted, regardless of NDEC, is always greater than or equal to 1.

If NDEC > 4, only the first four digits will have any meaning. This subroutine will handle floating point numbers whose integer part is less than 32768 and will write up to 4 digits to the right of the decimal point.

2.4.8 SCALE

This subroutine calculates a scale factor and a displacement factor.

Calling Sequence: CALL SCALE (ARR,NPTS,PGSZ,INC)

ARR — The name of the (floating point) array to be scaled.

NPTS — The number of points to be scaled in the array. Normally, all points are scaled. (Integer)

PGSZ — The size of the page (linear interval in inches) within which the data must fall. (Floating point)

INC — The increment at which the array is to be sampled. (Integer)

The calling FORTRAN program dimensions the array to have NPTS + 2 dimensions. The SCALE subroutine stores the displacement factor in ARR (NPTS+1) and the scale factor as ARR (NPTS+2). The scale factor and displacement factor are used by the subroutine DATA. (See below.)

2.4.9 DATA

The subroutine DATA with one call takes two arrays of equal size, one containing the X values and the second containing the corresponding Y values and produces the formatted data which when input to the plotter routines will plot each point.

Calling Sequence: CALL DATA (XARR, YARR, NPTS, INC, LTY, IEQ)

Parameters:

XARR The name of the array from which X values are to be extracted. (Floating point)

YARR The name of the array from which the Y values are to be extracted. (Floating point)

NPTS The number of data points to be plotted from each array to the end of the array. (Integer)

INC The increment at which the arrays are to be sampled. INC = 1 means every X, Y pair is plotted; INC = 2 means every other pair, etc. (Integer)

LTY Indicates the type of line desired.
- LTY<0: A symbol will be plotted at each selected point, but no lines will connect the symbols.
- LTY=0: A line will be drawn connecting each selected point. No symbols will be drawn.
- LTY>0: A symbol will be plotted at each selected point and a line will connect all symbols.

IEQ Positive integer designating symbol to be produced (1, 2, 3, 4, or 5). (Integer) (See Figure 2.1.)

If LTY = 0, IEQ has no meaning.

Prior to the call, the two arrays must be dimensioned to provide two extra locations at the end of each array. These locations must contain the displacement and the scale factor in that order.

The subroutine DATA will use these factors to operate on each floating point datum as follows:

$$X' = \frac{X(I) - \text{Displacement}}{\text{Scale Factor}}$$

OR

$$X' = \frac{X(I) - X(NPTS+1)}{X(NPTS+2)}$$

The subroutine SCALE (see above) will calculate these factors and store them in the proper locations. However, note that the scale factor for the X array and the scale factor for the Y array are independent of each other. The programmer can calculate these factors and store them in the proper location. Care should be taken with the sign of the displacement since it is a value to be subtracted from each datum.

2.4.10 AXIS

Subroutine AXIS produces an axis on the plot with tic marks every inch, an axis label and number labels for each tic mark.

Calling Sequence: CALL AXIS (X, Y, AXLH, IDIR, BCD, NCHAR, VLO, SF)

Parameters:

X, Y — The starting point on the page of the axis to be drawn. (Floating point)

AXLH — The length of the axis in inches. The value given will be truncated to the next smallest integer value. (Floating point)

IDIR — Axis direction. Zero for X direction. Non-zero for Y direction. (Integer)

BCD — The first word address of a character string to be plotted as a label for the axis. If there is no label, use a dummy space.

NCHAR — NCHAR is the number of letters contained in the character string to be plotted as a title. (Integer)

If NCHAR > 0, the title, tic marks, and interval labels will be plotted to the left of the vertical axis and above the horizontal axis.

If NCHAR < 0, the title, tic marks and interval labels will be plotted to the right of the vertical axis and below the horizontal axis.

VLO The number to be plotted at the starting point of the axis. By making VLO = ARR(NPTS+1), the axis and data will have the same starting point. (Floating point)

SF The scale factor (units/inch) to be used in labeling the 1 inch intervals. By making SF = ARR(NPTS+2) (see Scale routine), the axis and data will have the same scale factor. (Floating point)

NOTES:

1. The intervals labels will be scaled by powers of 10 if they are too large or small to fit into 2 decimal place accuracy. Thus, assuming a scale factor of 1000./inch, 12000. would be printed 12.00 on the interval tic mark, but a note would be added to the axis label: "*10^3."

2. The SCALE routine should be used prior to using AXIS if SF = ARR(NPTS+2) and VLO = ARR(NPTS+1).

2.4.11 CLOSE

The subroutine CLOSE will output the last partial record which contains the software end-of-file mark and will rewind the mass storage device.

Calling Sequence: CALL CLOSE

This call must be the last statement in each data generation FORTRAN calling program.

2.5 Sample FORTRAN Calling Program

See Figure 2.2.

2.5.1 Problem Statement:

Produce a plot of X = SIN Y as Y varies from 0 to 8π.

2.5.2 Program Listing

```
DIMENSION X(723),Y(723)
DATA X(722),X(723)/-1.,.5/
J=0
DO 1 I=1,1441,2
J=J+1
```

```
      Y(J)=(FLOAT(I-1))*3.14159/180.
    1 X(J)=SIN(Y(J))
      CALL OPEN
      CALL ORIG(1.,.9)
      CALL SCALE(Y,721,13.,1)
      CALL DATA(X,Y,721,1,0,1)
      CALL AXIS(0.,0.,4.,0,6HSIN(Y),6,-1.,X(723))
      CALL AXIS (2., 0., 12., 1, 1H , -1, Y(722), Y(723))
      CALL CHAR(-.5,6.5,1HY,2,1,-1)
      CALL CLOSE
      STOP
      END
```

2.5.3 Explanation of Calls

DATA X(722),X(723)/-1.,.5/
Set up the X displacement and the X scale factor. The displacement of -1 units is necessary to insure all X values output for plotter will be positive. The scale factor of 1/2 units/inch is arbitrary.

CALL OPEN
Initializing routine

CALL ORIG(1.,.9)
Offsets the origin by 1 inch in the X direction and 0.9 inches in the Y direction. This allows room to the left of the plot and below the plot for axis labels. All data processed will be with respect to this new origin.

CALL SCALE(Y,721,13.,1)
Scales all 721 values in the Y array to fall between 0 and 13 inches by calculating a displacement and scale factor and storing these values in Y(722) and Y(723) respectfully. The Y values vary from 0 to about 25.1 yielding a scale factor of 2 units/inch and a displacement of zero.

CALL DATA(X,Y,721,1,0,1)
Processes each value in each array by subtracting the displacement and dividing by the scale factor, and then generates and outputs the formatted data for input to the plotter routines for each of the 721 points.

CALL AXIS (0., 0., 4., 0, 6H SIN(Y), 6, -1., X(723))
Generates and outputs formatted data for the plotter routines to draw the X axis tic marks, axis label, and interval labels. The axis is to be started at the relative

origin (0.,0.) to be 4 inches long, and to be labeled SIN(Y). The number of characters argument is positive causing the labeling to be done to the left of the axis. The label for the starting point of the axis is -1. and the same scale factor is used as is used in the DATA call.

CALL AXIS (2.,0.,13.,1,1H ,-1,Y(722), Y(723))

Generates and outputs formatted data for the plotter routines to draw the Y axis, tic marks, and the interval labels. The axis is started at the origin of the sine plot. Since the displacement is -1 units in the X direction and the scale factor is 1/2 unit/inch, the origin of the sine plot is 2 inches above the relative origin of the plot area. In the Y direction there is no difference between the sine plot origin and the relative origin of the plot area since the Y displacement, Y(722), is zero.

No axis label is desired since the axis subroutine would print the label close to the axis which in this case would interfere with the graph. In some cases when no label is desired, the "number of characters" argument can equal zero and the ASCII argument can be a dummy argument. However in this case, in order to print the tic marks and the interval labels below the axis, the "number of characters" argument must be negative. A label of one ASCII blank is therefore called for with the "number of characters" argument being -1.

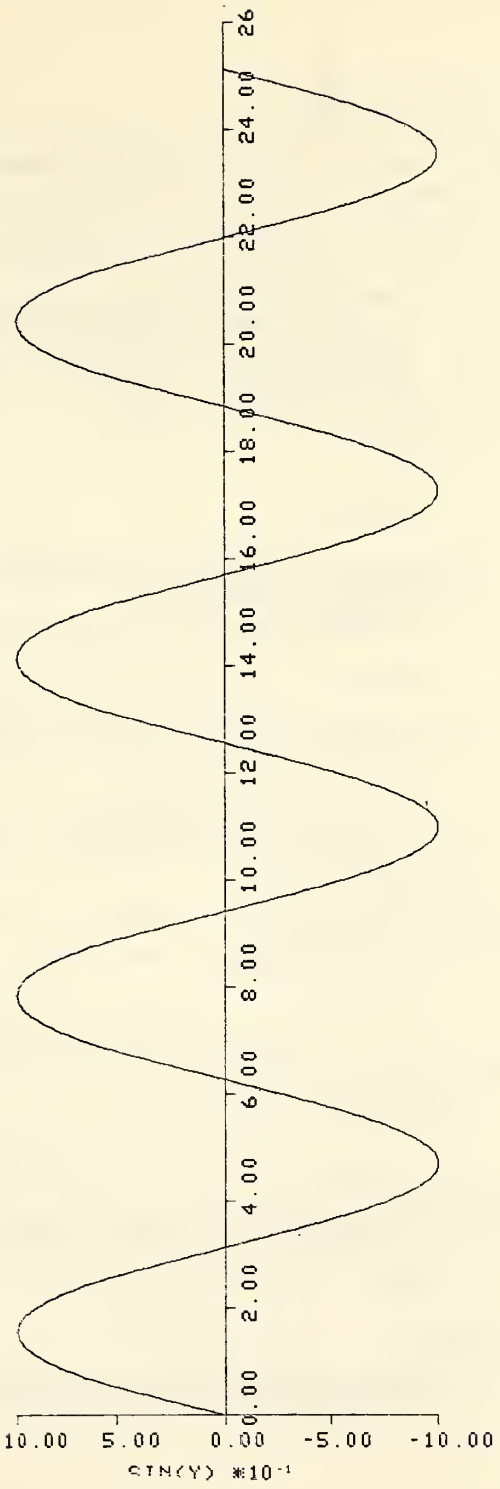
The scale factor is the same as used in the DATA call.

CALL CHAR (-.5, 6.5, 1HY, 2, 1, -1)

Produced a label for the Y axis below the graph area. Since the relative origin of the graph area in the X direction is offset one inch above the origin of the plot area, the X coordinate Y -.5 will position the label 1/2 inch below the graph area but will fall within the plot area.

CALL CLOSE

Outputs the last partial buffer to the mass storage device.



SAMPLE OUTPUT
FIGURE 2.2.

2.6 Loading Procedures

The data formatting calling program is loaded with the OS library loader.

1. Compile the FORTRAN calling program.
2. Assign logical units to
   a. FORTRAN calling program (object) (LU)
   b. User's subroutine (object) if any (LU')
   c. Special run time library (LU'')
   d. FORTRAN run-time library (LU''')
3. Load the OS library loader
4. Start loader
5. Set bias

   BIAS bbbb

   where bbbb is the desired program origin expressed in hexadecimal notation.
6. Load FORTRAN calling program (object)

   LOAD LU

7. Link FORTRAN user subroutines, if any

   LINK LU' (as required)

8. Edit special run-time library

   EDIT LU''

9. Edit the FORTRAN run-time library

   EDIT LU'''

10. Produce a memory map

    MAP LU

    Memory map is output on logical unit LU.

11. Return control to operating system.

    END

2.7 Execution

1. Assign logical unit A to a scratch area on a

mass storage device or to a paper tape punch device.

NOTE: Operating system must be generated to include at least 12 logical units to allow logical unit A to be used.

2. Start at the program origin.

The program will output the unsorted data formatted for input to the plotter routines on logical unit A.

2.8 Error Messages

2.8.1 I/O Errors

These messages are produced if an I/O error is encountered during an attempt to output to logical unit A. The xxxx is the status byte.

1. DEVICE UNAVAILABLE xxxx
   Cause: Device not on line
   Program response: Pause
   Operator response: Turn on device, type CONTINUE

2. BEGIN/END OF DEVICE xxxx
   Cause: End-of-medium encountered
   Program Response: Terminate run and return control to operating system
   Operator response: Assign a larger scratch area to logical unit A and restart program at origin.

3. I/O ERROR xxxx
   Cause: Unrecoverable error
   Program response: Terminate run and return control to operating system

2.8.2 Data Errors

A data error message is produced when the value of a floating point coordinate is outside the range handled by the data formatting subroutines

DATA ERROR xxxx

The value of xxxx indicates which coordinate and in which subroutine the error occurred.

ERROR MESSAGE	COORDINATE	SUBROUTINE	RESPONSE
Data Error 0103	X	CHAR	Data ignored*
Data Error 0104	Y	CHAR	Data ignored*
Data Error 0203	X	VECT	Data ignored*
Data Error 0204	Y	VECT	Data ignored*
Data Error 0303	X	CURR	Program terminated. Control returned to operating system.
Data Error 0304	Y	CURR	Program terminated. Control returned to operating system.
Data Error 0403	X	ORIG	Program terminated. Control returned to operating system.
Data Error 0404	Y	ORIG	Program terminated. Control returned to operating system.

* After 20 data error messages from either CHAR or VECT, the program is terminated and control is returned to the operating system. This feature can be altered by changing the maximum error count. The constant is at location X'28' relative to the entry point OPEN.

3. PLOTTER ROUTINES

3.1 General

The plotter routines, started at the origin will:

1. Calculate and request as much core as is available for use as the data buffer.
2. Read the entire data file from the mass storage device into the data buffer.
3. Sort the entire file in descending order.
4. Output the entire sorted file to the mass storage device.
5. Read the sorted data from the mass storage device, one record at a time.
6. Convert from vector format to raster format.
7. Output the raster data to the printer/plotter through driver routines.
8. Read and process consecutive records until end-of-file is reached.

9. Release buffer storage and return control to the operating system.

3.2 Data Formats

Data to be read by the plotter routines must be in either Vector Format or Character Format. Each set of data are contained in 8 bytes.

3.2.1 Vector

A set of vector data (see Figure 3.1) consists of end point X and Y co-ordinates represented as positive integers in plotter units (100 plotter units per inch).

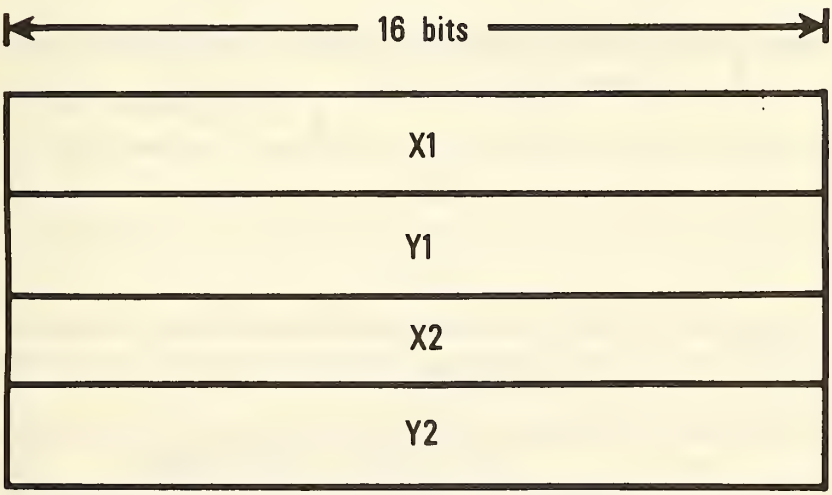


FIGURE 3.1.

The plotter routines will sort in descending order and therefore X1 will be greater or equal to X2. This is also true if data files are generated on other computers and presorted in descending order. However, if the files are presorted in ascending order, then X2 must be greater or equal to X1.

3.2.2 Characters

Character format (see Figure 3.2) consists of X and Y co-ordinates as positive integers in plotter units (100 plotter units per inch), a code indicating that the data is character data, the ASCII code of the character, and information indicating the size and orientation of the character.

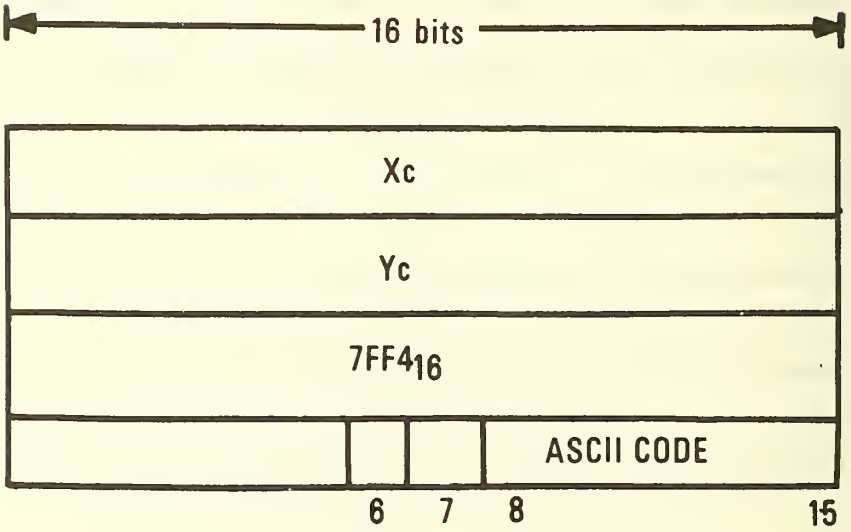


FIGURE 3.2.

Bit number 6 of the fourth word determines the size of the character:

BIT 6 = 0 for small characters
BIT 6 = 1 for large characters

Bit number 7 of the fourth word determines the orientation of the character:

BIT 7 = 0 for upright characters
BIT 7 = 1 for sideways characters

The X and Y coordinate refer to the upper left-hand corner of an upright character and the lower left-hand corner of a sideways character as shown in Figure 3.3

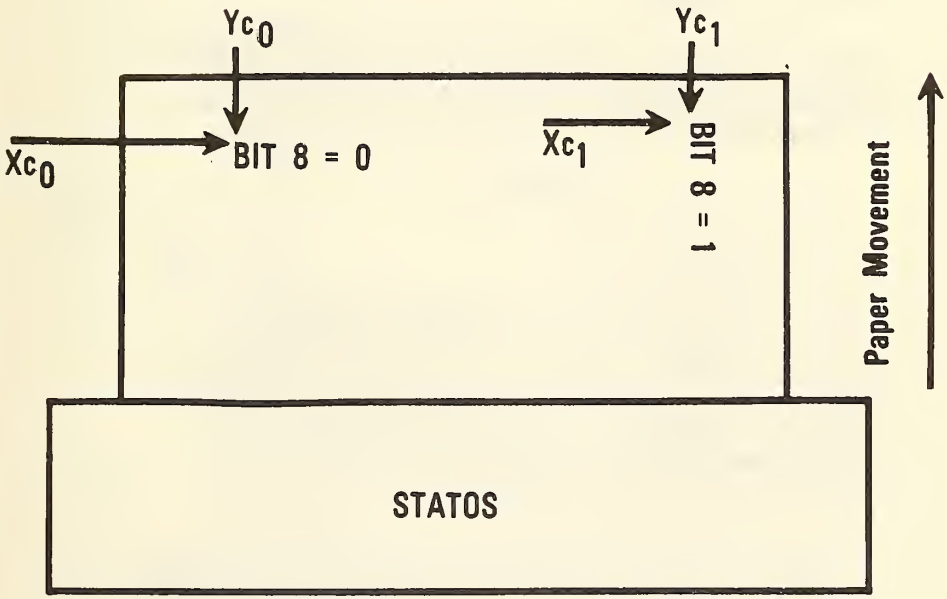


FIGURE 3.3.

C_0 in Fig. 3.3 refers to bit 7 = 0 in Fig. 3.2.
C_1 in Fig. 3.3 refers to bit 7 = 1 in Fig. 3.2.

3.3 Size of Data Buffer

Each record is 512 bytes long. The number of records, N, that can be handled is defined as

$$N = \text{integer } \frac{(\text{available core} - 2)}{512} \text{ bytes}$$

Each set of data (vectors or characters) require 8 bytes (see Section 3.2). The file is terminated with a software end-of-file mark (X'7FFF'). The amount of data that can be contained in the buffer for the sort is 64*N sets. Data in excess of this amount will be lost. The number of records of sorted data output to a mass storage device will equal the number of records read except when the buffer is full in which case N+1 records are output.

There is no limit to the number of records that can be read in for conversion from vector to raster format. However, the number of sets which can be handled on any given plotted line is

$$\frac{512(N-1) + 2}{12}$$

3.4 SORT

The sort routine will sort the entire file on the first halfword of each 4 halfword sets of data in descending order. The sort is therefore on X for character sets and on X1 for vector sets. The vector data was formatted during the data formatting sub-routines so that $X1 \geq X2$ in each set.

3.5 Operating Considerations

The plotter reads the formatted input data produced (for example) by the data formatting routines. It sorts the data and writes it out again. It then rereads the data one records at a time for plotting. All of these operations are done using supervisor calls compatible with Interdata operating systems (see sections 3.7.1 and 3.7.2).

Communications with the printer/plotter are done using stand-alone drivers as supplied by the manufacturer and modified at NBS. As such, the protect mode of the CPU as enabled by the OS prevents this communication.

To remedy this deficiency, it is necessary to turn off the protect bit.

3.5.1 OS MODIFICATION (BOSS) METHOD

Change the contents of location UPSW from X'3D00' to X'3C00'. This modifies the user PSW provided by the START command so that protect mode is disabled.

Similar procedures will work for other OS but will cause difficulty in a real-time environment. Use of this package implies dedication of the CPU to the Statos 31 for the duration of the run.

3.5.2 PROGRAM METHOD

The following program will turn off the protect bit and jump to the plotter routines. If an SVC 0 is used anywhere else in the system, care must be taken to restore it.

```
PROFF   LH 0,X'9A'                      Get new PSW for SVC's
        NHI 0,X'FEFF'                   Kill protect bit
        STH 0,X'9A'                     Put new PSW back
        LHI 0, (absolute address of     Get start addr. of plotter
              origin of plotter)
        STH 0,X'9C'                     Put in new PSW (loc) for SVC 0
        SVC 0,0                         Do the SVC 0
```

This program will disable protect mode, but the OS will restore it the next time the START command is executed unless the modification of section 3.5.1 has been made.

3.6 Procedure for Loading

The load-module is loaded with the OS resident loader. (This example is for BOSS.)

```
BIAS xxxx
```

where xxxx is the desired program origin expressed in hexadecimal notation.

LOAD pa

where pa is the physical address of the device from which the program is to be loaded.

3.7 Execution

3.7.1 With Mass Storage Device

1. Assign logical unit A to the input file.
2. Assign logical unit 9 to a scratch area where the sorted data can be written.
3. Turn on the Varian printer/plotter
4. Start plotter routines at origin.

The program will read the entire data file from logical unit A, sort the data, write the sorted file on logical unit 9, read and process consecutive records from logical unit 9, position paper in printer to top of page, output raster data to the plotter and return control to the operating system.

3.7.2 With Paper Tape Device

1. Assign logical unit A to the paper tape punch/reader.
2. Assign logical unit 9 to the paper tape punch/reader.
3. Load input tape into the paper tape reader.
4. Turn on printer/plotter, paper tape reader and paper tape punch.
5. Start plotter routines at origin.

The program will read the input tape, sort the data and output the sorted data to the paper tape punch device.

6. Turn off the paper tape reader as soon as the read operation is complete and before the punch operation is complete.

The program will produce the messages:

DEVICE UNAVAILABLE xxxx
PAUSE

7. Load the tape of sorted data into the paper tape reader, turn on reader.

8. Type CONTINUE

The program will read and process consecutive records from this tape, output raster data to the plotter and return control to the operating system.

3.7.3 SORTED FILES

1. Assign logical unit 9 to the sorted file.

2. Start at ORIGIN + 8

If the file was sorted on another computer in ascending order, the program will print a message to the operator indicating an ascending sort and will plot the complement of the data.

3.8 Error Messages

3.8.1 I/O Errors

These messages are produced if an I/O error is encountered during the read or the write operations.

xxxx is the status byte.

1. DEVICE UNAVAILABLE xxxx
   (See Section 2.8.1)

2. BEGIN/END OF DEVICE xxxx
   (See Section 2.8.1)

3. I/O ERROR xxxx
   (See Section 2.8.1)

4. EOF ENCOUNTERED IN VECTOR FILE xxxx
   Cause: A file mark has been read during binary input.
   Program response: Terminate run and return control to operating system.

3.8.2 Plot Error

1. VECTOR FILE TOO LARGE
   Cause: Data file input from logical unit A is too large.
   Program response: Continues to process all data in buffer. Additional data is lost.

2. CURRENT VECTOR FILE OVERFLOW
   Cause: The number of sets of data to be plotted on the current line is too large.
   Program response: Continues to process all data in buffer. Additional sets of data for that current line are lost.

3. PLOT ERROR xxxx
   where xxxx indicates the cause of the plot error.

   Plot errors occur when there is no data in the file or when the data is either out of range or in incorrect order.

ERROR MESSAGE	CAUSE	PROGRAM RESP&ONSE
Plot Error 0000	No data in file	Terminates run and returns control to operating system.
Plot Error 0001	No positive X data in file	Terminates run and returns control to operating system.
Plot Error 0002	Data out of order	Data ignored and run continues*
Plot Error 0003	X value out of range	Data ignored and run continues*
Plot Error 0004	Y value out of range	Data ignored and run continues*

The operator should check logical unit assignments. Failure to assign a physical address to logical unit A produces PLOT ERROR 0000. Assigning meaningless files to logical unit A or logical unit 9 will cause many error messages.

* After 20 PLOT ERRORS the run is terminated and control returned to the operating system.

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16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

A description is given of Dataplot 70, a program which enables plotting 1) lines between pairs of X-Y coordinates and 2) a string of ASCII characters at a given X-Y coordinate on the electrostatic printer/plotter. Detailed instructions are provided enabling the user to 1) convert data to plotter format, 2) draw axis, 3) label axis, 4) scale data, 5) handle arrays, 6) produce symbols at end points, and 7) offset the origin. Hardware and software requirements as well as loading and operating instructions are given.

A sample FORTRAN calling program is included and each instruction is explained in detail. The output of the calling program is shown. Error messages produced by Dataplot 70 are explained.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Digital plotter; graph; graphics; minicomputer; plotter

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