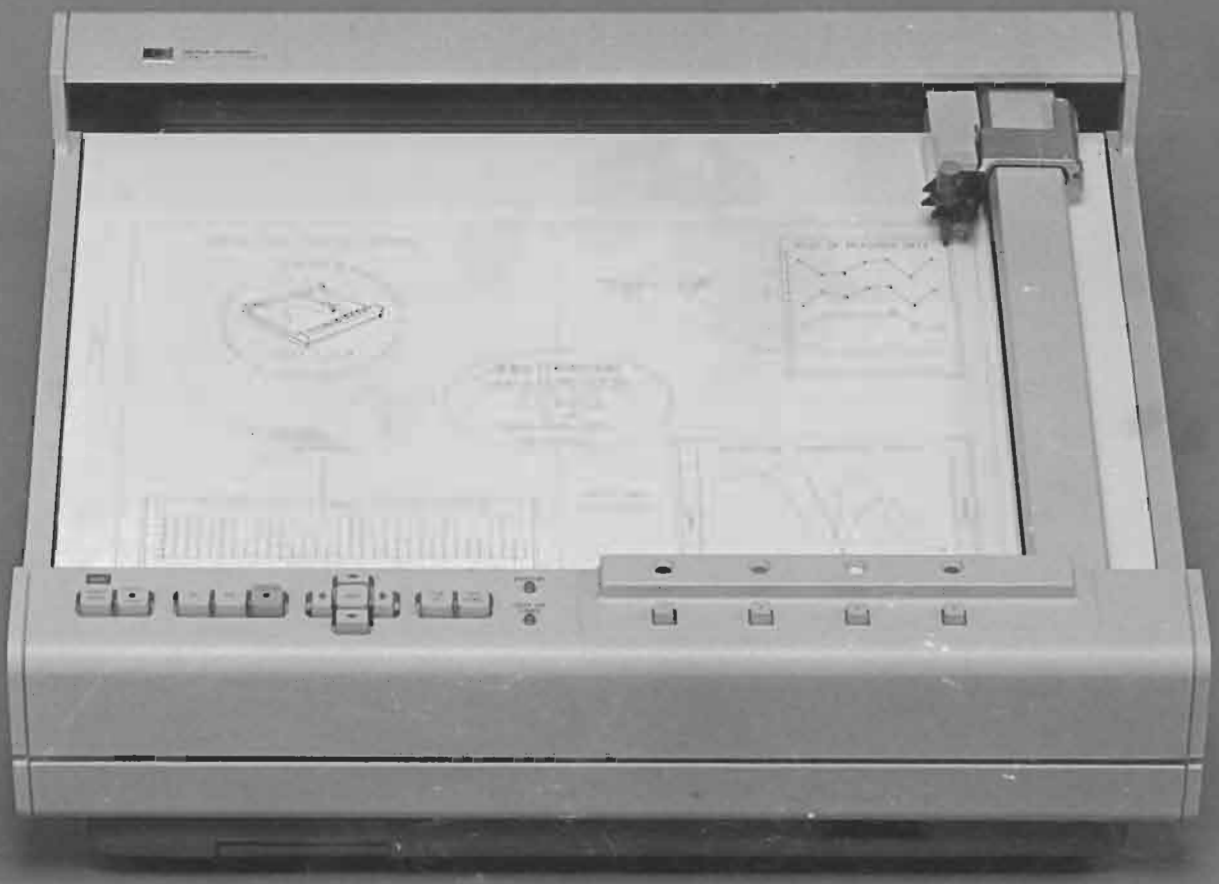
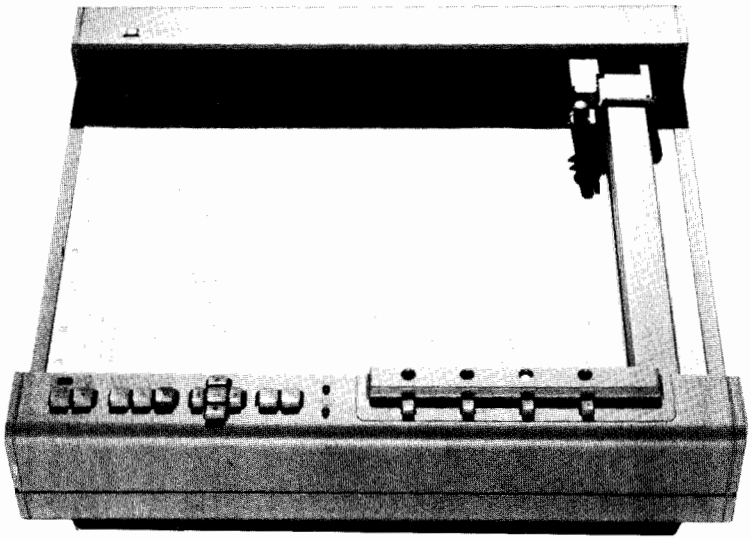
Hewlett-Packard 9872A Graphics Plotter

Interfacing and Programming Manual



9872A Plotter Interface and Programming



HP 9872A GRAPHICS PLOTTER

Hewlett-Packard
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(For World-wide Sales and Services Offices see appendix)

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Manual Summary

Chapter 1: General Information

Information about setting up the plotter and the methods of addressing, sending, and receiving data over the Hewlett-Packard Interface Bus.

Chapter 2: Plotting

Describes the instructions used in plotting.

Chapter 3: Lettering

Describes the instructions used in lettering. Included are instructions to vary the size, width, and slant of the characters.

Chapter 4: Graph Enhancement

Describes the instructions used to enhance the plot.

Chapter 5: Digitizing

Describes the instructions used to digitize with the plotter and perform interactive digitizing communication with the controller.

Chapter 6: Additional Plotter Control

Describes the additional plotter control instructions for pen control, character control, plotter configuration and status, and external plotter commands.

Chapter 7: Scaling

Describes the instructions for locating the scaling points and includes some scaling examples.

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Chapter 1
General Information

Introduction

This manual contains interfacing and programming information for the Hewlett-Packard 9872A Graphic Plotter. The manual is organized into seven chapters and an appendix as follows:

Chapter 1 – General Information
Chapter 2 – Plotting
Chapter 3 – Lettering
Chapter 4 – Graph Enhancement
Chapter 5 – Digitizing
Chapter 6 – Additional Plotter Control
Chapter 7 – Scaling
Appendix

Before using this manual, you should be thoroughly familiar with the controller and its programming language.

The following conventions apply to the command syntax used within this manual:

DOT MATRIX – All items in dot matrix are required exactly as shown.
( ) – All items in parentheses are optional.

Description

The Hewlett-Packard 9872A is a microprocessor-based HP-IB plotter that produces high quality, multi-color graphic plots on any size chart up to 280 X 432 mm (ISO A3). The 9872A offers exceptional line and character quality with addressable moves as small as 0.025 mm (0.001 in.). Thirty-eight different instructions are built in to equip the plotter with such capabilities as point digitizing, labeling, character sizing, and window plotting. The 9872A is interfaced through the Hewlett-Packard Interface Bus (conforms to IEEE 488-1975). With HP-IB, you can connect the plotter to your HP-IB compatible calculator, computer, or other controller using a standard interface cable. Short, easily understood commands and the HP-IB interface enable you to start plotting with only a minimum of programming experience.

Trace identification is enhanced by the use of the 9872A's automatic selection of any of four pens through either program control or front panel pushbuttons. Seven different dashed-line fonts, symbol mode plotting, and user-defined characters aid in trace identification.

Faster, high quality plotting is another contribution of the 9872A. The pen speed is programmable to any one of 36 speeds from 10 mm/s to 360 mm/s. This feature enables you to produce high quality graphics on standard chart paper as well as other media. Typical character plotting speed of three characters per second enables you to produce fully lettered graphs in less time than before.

The 9872A is designed to be especially useful in the areas of statistics, medicine, numerical control, surveying, and engineering design. Whether tabulated, measured, or computed data, the 9872A enables you to quickly prepare multicolor plots of excellent line quality and high resolution. Five different character sets, including three European sets, provide application worldwide.

Setting Up The Plotter

Information concerning power requirements, grounding, and plotter maintenance is contained in the HP 9872A Plotter Operating and Service Manual supplied with your plotter.

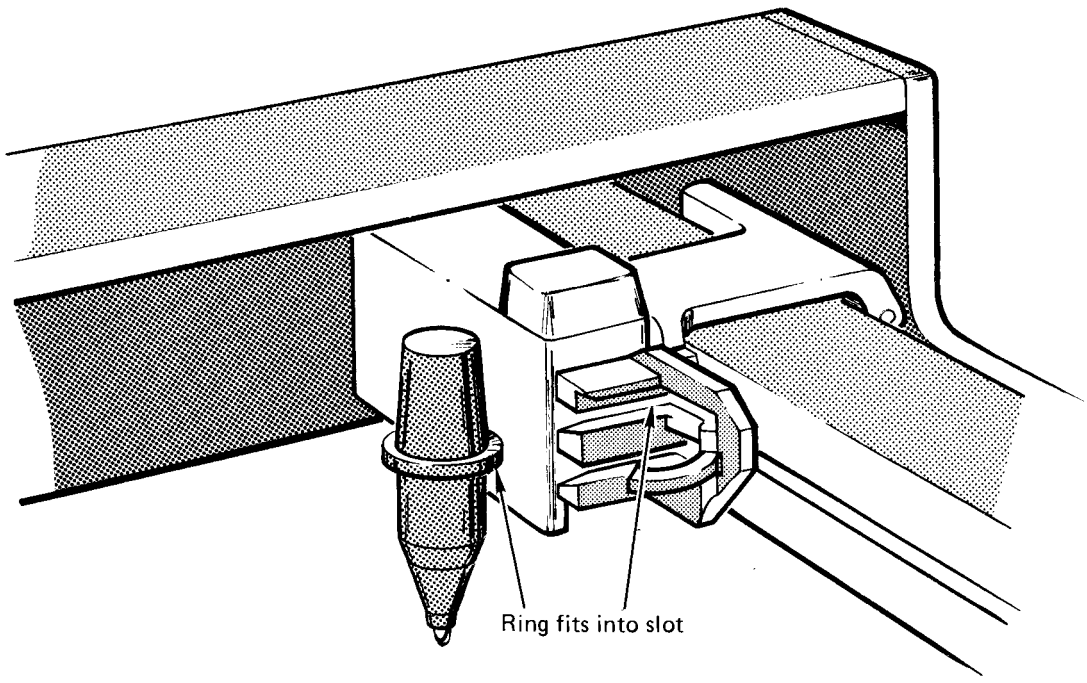
Turning The Power On

After observing the proper power and grounding requirements and precautions specified in the Operating and Service Manual, set the LINE switch to ON (1). The following will then occur:

a. Pen is raised.
b. Pen moves to lower right corner.
c. Chart hold is on.
d. Certain parameters are set to their default values. For a description, see the DF instruction (Chapter 6).

Loading Pens

After the plotter's initialization process is complete and the plotter arm has stopped moving, you can install the pens.



Installing The Pens

WARNING

To avoid the possibility of injured fingers, always keep your hands away from the pen stable and plotter arm when operating the front panel controls.

Select the color of pen that you want in pen storage location 1, remove the cap and place it in the pen holder as shown in the picture above. Note that the thick ring around the middle of the pen fits into the slot in the pen holder. Now press [ENTER O] and pen location button [1]. The plotter arm will put the pen in the first storage location. Repeat this procedure with three more pens, substituting the appropriate pen location button for each one.

Loading Paper

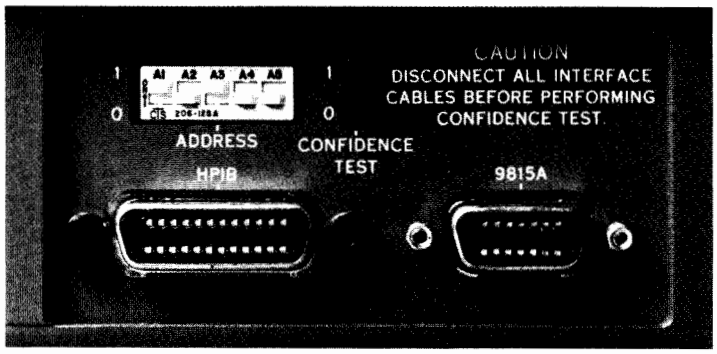
To load paper, you first press [CHART O LOAD]. This releases the paper hold-down mechanism and moves the plotter arm to the upper right corner of the platen. Lay a sheet of paper on the platen surface and smooth it out. Make sure that the paper is positioned squarely against the ridge at the bottom of the platen. Now press [CHART HOLD]. This will activate the paper hold-down mechanism.

The Plotter Address Code

Since each HP-IB interface can have as many as 14 devices connected to it, each device must be set to a specific address code.

The plotter can be set to any one of 31 HP-IB addresses ranging from 0 thru 30. Each address can be selected by setting the switches on the plotter back panel to the appropriate binary bit positions for the particular address value desired.

The plotter is set to an address code of 05 at the factory. This corresponds to a listen character of % and a talk character of E. Check your plotter for the proper switch positions shown below.



Plotter Address Switches

The following table lists the switch positions for each address value.

Address Switch Positions

Address Restricted to These Codes When Using Parallel Poll Capability

Address Characters		Address Switch Settings					Address Codes	
Listen	Talk	A5	A4	A3	A2	A1	decimal	octal
SP	@	0	0	0	0	0	0	0
!	A	0	0	0	0	1	1	1
"	B	0	0	0	1	0	2	2
#	C	0	0	0	1	1	3	3
$	D	0	0	1	0	0	4	4
%	E	0	0	1	0	1	5	5 ← preset
&	F	0	0	1	1	0	6	6
'	G	0	0	1	1	1	7	7
(	H	0	1	0	0	0	8	10
)	I	0	1	0	0	1	9	11
*	J	0	1	0	1	0	10	12
+	K	0	1	0	1	1	11	13
,	L	0	1	1	0	0	12	14
-	M	0	1	1	0	1	13	15
.	N	0	1	1	1	0	14	16
/	O	0	1	1	1	1	15	17
0	P	1	0	0	0	0	16	20
1	Q	1	0	0	0	1	17	21
2	R	1	0	0	1	0	18	22
3	S	1	0	0	1	1	19	23
4	T	1	0	1	0	0	20	24
5	U	1	0	1	0	1	21	25
6	V	1	0	1	1	0	22	26
7	W	1	0	1	1	1	23	27
8	X	1	1	0	0	0	24	30
9	Y	1	1	0	0	1	25	31
:	Z	1	1	0	1	0	26	32
;	[	1	1	0	1	1	27	33
<	/	1	1	1	0	0	28	34
=	]	1	1	1	0	1	29	35
>	^	1	1	1	1	0	30	36

Front Panel Controls

The front panel controls provide a convenient means for operator interaction with the plotter. A brief description of the controls and their function follows:

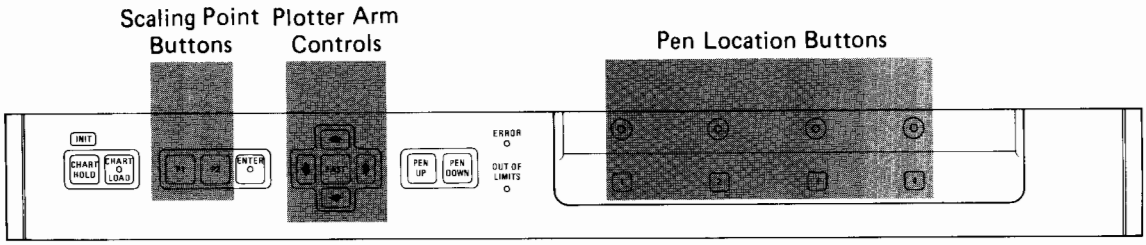


CHART HOLD Pushbutton — Activates the electrostatic paper hold-down. When pressed after pressing the ENTER pushbutton, the plotter is initialized.

CHART LOAD Pushbutton — Moves the pen to the upper right-hand corner of the platen and deactivates the paper hold-down. When pressed, the lamp turns on.

Scaling Point Pushbuttons P1 and P2 — Pressing P1 or P2 directs the pen to move to the corresponding physical point on the platen. Pressing the ENTER pushbutton prior to P1 or P2 defines the current pen position as the corresponding physical point on the platen. See Setting The Scaling Points (Chapter 1).

ENTER Pushbutton — A multipurpose pushbutton which flashes when pressed and is used as follows:

a. Initializes the plotter when CHART HOLD is pressed after ENTER.

b. Resets scaling points P1 and P2 when P1 or P2 is pressed after ENTER.

ENTER Pushbutton (Cont.)

— c. Enters a digitized point when in the digitize mode.

d. Stores a pen into the stable when a pen select pushbutton is pressed after ENTER.

e. ENTER may be cleared by pressing any of the plotter arm control pushbuttons.

Plotter Arm Controls

— Pressing any button will move pen in the direction indicated at 4 mm/s. The pushbuttons can be used in X and Y combinations. When the FAST pushbutton is operated with a direction pushbutton, the pen moves at 88 mm/s. Operating any front panel position control will clear a flashing ENTER pushbutton lamp.

PEN UP, PEN DOWN Pushbuttons

— Used to raise or lower the pen. These pushbuttons may be used to override program pen instructions during operation under program control.

ERROR Lamp

— Is lighted when one of the following occurs:

a. Instruction not recognized — Error 1
b. Wrong number of parameters — Error 2
c. Bad parameter — Error 3
d. Illegal character used — Error 4
e. Unknown character set requested — Error 5
f. Position overflow occurred — Error 6.

OUT OF LIMITS Lamp

— Provides the following indications:

a. When flashing, indicates that the numerical position commanded by the controller exceeds the capability of the plotter. Maximum numerical limits in the X and Y axis are ±32767 plotter units.

OUT OF LIMITS Lamp (Cont.)

— b. When steady, indicates that the numerical position commanded by controller is between the maximum capacity of ±32767 plotter units and a defined "window" that is described in the Input Window instruction (Chapter 6).

c. When off, indicates that the numerical position commanded by the controller is within the defined "window."

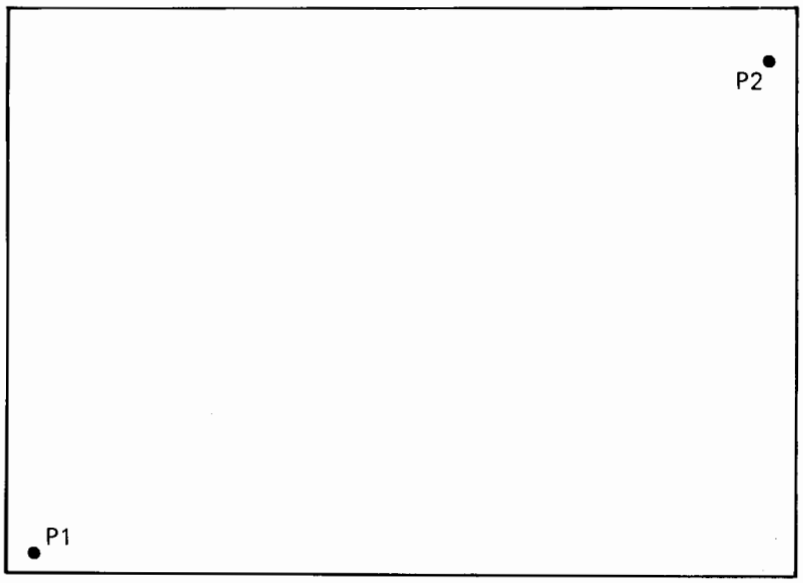
Pen Select Switches

— Used for manual selection of pens. These switches may be used to change pens while a program is running. Pen will change upon completion of the instruction being executed. When pressed after pressing the ENTER pushbutton, the pen in the pen holder will be stored and capped in the selected location.

Setting The Scaling Points

The scaling points, P1 and P2, do not restrict the plotter arm motion, but can be used to establish the scaling area.

When the plotter is initialized, it sets P1 and P2 as shown in the next figure.



Initialized Location of P1 and P2

To relocate either or both of these points, use the following procedure:

Position the pen at the new location using the plotter arm controls.

When the pen is at the desired location, press [ENTER O] and either [P1] or [P2] according to the point that is to be located there.

Bus Command Statements

Most operations of bus devices are controlled using the BUS COMMAND statement. BUS COMMAND is the primary statement for addressing a talker and listeners to send and receive data and for programming instruments.

Each controller has a designated mnemonic which serves as the BUS COMMAND. For example, the HP 9830A Calculator uses the mnemonic CMD. The basic form of the BUS COMMAND statement is

CMD" <Command String>" [, " <Program Code String>"]

where the portion within the brackets is optional. Actually, command strings and program code strings may follow CMD in the general form

CMD" <Command String>", " <Program Code String>",
" <Command String>", " <Program Code String>", . . .

The last program code string is optional. The command string is used to address a talker and listeners. The program code string is used to transmit remote programming instructions to a device.

Addressing The 9872A As A Talker Or Listener

The calculator addresses devices to talk or to listen by using the appropriate address codes within the command string. A command string contains a sequence of address codes and bus command codes.

The basic addressing sequence is

< Unlisten Command >< Talk Address >< Listen Addresses >

This sequence is made up of three major parts which serve the following purposes:

1. The unlisten command is the universal bus command with a character code of "?". It unaddresses all listeners. After the unlisten command is transmitted, no active listeners remain on the bus.

2. The talk address designates the device that is to talk. A new talk address automatically unaddresses the previous talker.

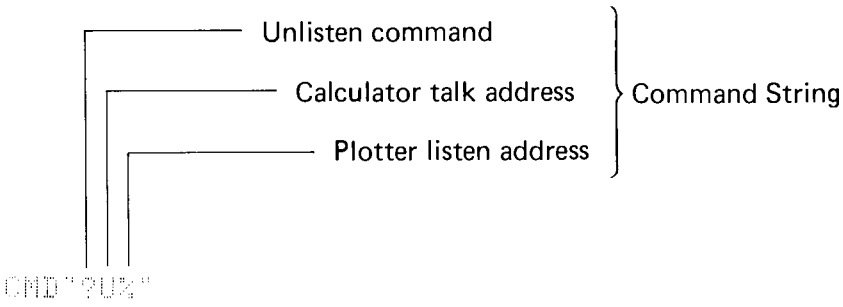
3. The listen addresses designate one or more devices that are to listen. A listen address adds the designated device as a listener along with other addressed listeners.

This basic addressing sequence simply states who is to talk to whom. The unlisten command ("?") plays a vital roll in this sequence. It is important that a device receive only the data that is intended for it.

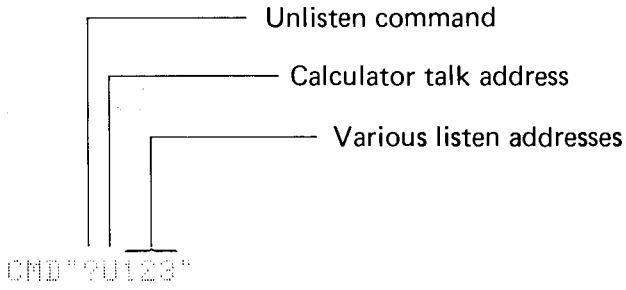
When a new talk address is transmitted in the addressing sequence, the previous talker is unaddressed. Therefore, only the new talker can send data on the bus and there is no need to routinely use an untalk command in the same manner as the unlisten command.

When using the CMD statement to address devices on the bus, each code in the command string is transmitted and obeyed in the order written. The following examples use the 9830A calculator to address the 9872A plotter.

Example 1: Basic addressing sequence:



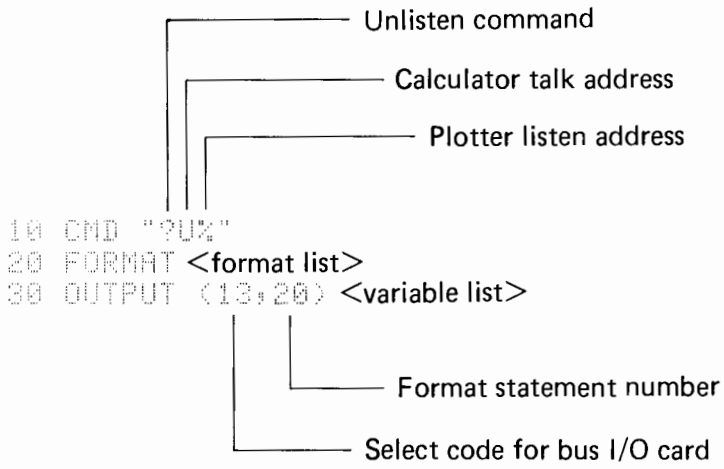
Example 2: Basic addressing sequence with multiple listeners:



Sending And Receiving Data

Controller-To-Plotter

Transmitting data from the controller to the plotter is typically accomplished using WRITE, PRINT@, or OUTPUT statements, depending on the controller used. The 9830A uses the OUTPUT statement as follows:

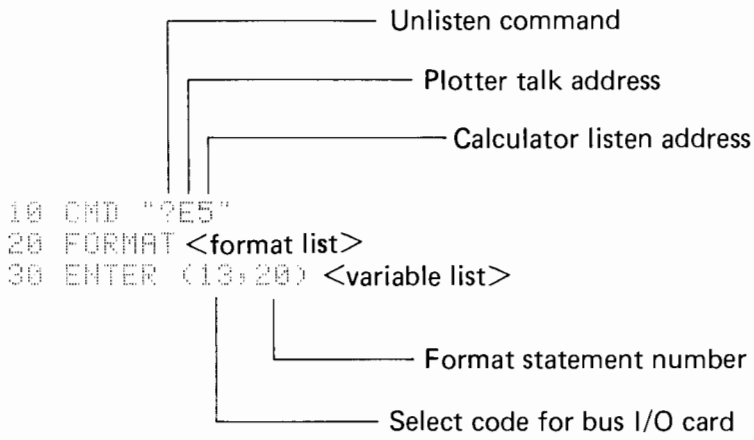


In this case, the CMD statement addresses the calculator to talk and the plotter to listen. The OUTPUT statement transmits the variable list in accordance with the FORMAT statement.

The result of using controllers that employ WRITE or PRINT@ statements is the same as OUTPUT as long as the proper characters are sent over the bus to form either command or data strings.

Plotter-To-Controller

Transmitting data from the plotter to the controller is usually accomplished using READ, INPUT, or ENTER statements, depending on the controller used. For most applications, the 9830A uses the ENTER statement as follows:

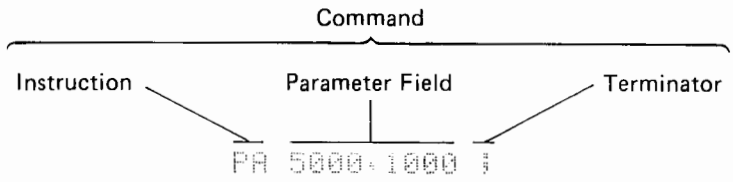


In this case, the CMD statement addresses the plotter to talk and the calculator to listen. The ENTER statement takes the incoming data and stores the data items into the variables specified in the variable list.

After outputting the desired information from the plotter to the controller, in order to get the controller to again talk and the plotter to listen, you must send the proper talk and listen addresses.

The 9872A Instruction Set

The instruction set for the 9872A plotter consists of 38 Hewlett-Packard Graphic Language (HPGL) instructions which fall into 7 basic groups. A command is defined as an instruction followed by its parameter field and a terminator as shown in the following example:



Each instruction is a two-letter mnemonic which can be either upper or lower case. The parameter field can be of three types:

1. Integer Format: Integers between -32768 and +32767. No decimal is allowed. If no sign is specified, the parameter is assumed to be positive.

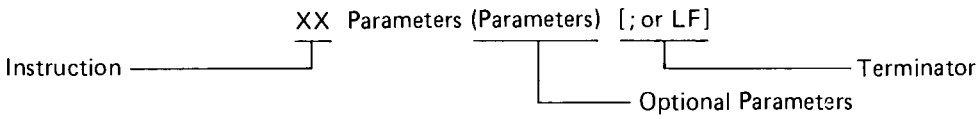
2. Decimal Format: Numbers between ±127.999 with an optional decimal. Fractional inputs less than 0.004 are represented as zero. If no sign is specified, the parameter is assumed to be positive.

3. Label Fields: Any combination of text, expressions, or string variables. Refer to the label instruction LB (Chapter 3) for a complete description.

A terminator must be sent at the end of the parameter field for all instructions. For all instructions except LB, the terminator must be either a semi-colon or line feed. Some systems automatically send the terminator at the end of the parameter field. The syntax used throughout this manual will use [; or LF].

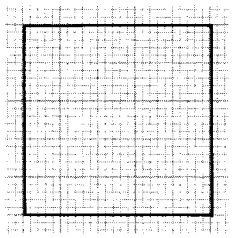
When using the label instruction LB, the terminator used must be a binary 3 (ETX).

Certain instructions (such as PA or PR) may have multiple parameters. These parameters must be separated by commas and must conform to a particular syntax. The syntax is listed under the respective instruction definition in the following chapters and will take the general form:



Consider the following program using the 9830A calculator as an example of some typical instructions, parameter fields, and terminators:

```
10 CMD "?U%"
20 OUTPUT (13,*)"SP1;PA5000,5000;PD"
30 OUTPUT (13,*)"PR0,1000,1000,0,0,-1000,-1000,0;PU;SP0"
40 END
```



Line 10 unaddresses all listeners (?) and establishes the 9830A as the talker (U) and the 9872A as the listener (%).

Line 20 causes the plotter to select pen #1 (SP1), move to the absolute platen position X=5000, Y=5000 plotter units, and then puts the pen down (PD).

Line 30 moves the pen relative (PR) to the position commanded in line 20 in X,Y pairs first 0,1000 plotter units, then 1000,0 plotter units until it has drawn a square of 1000 plotter unit sides. The pen is then picked up (PU) and returned to the stable (SP0).

Note the use of the terminator ; between commands. The terminator is not necessary at the end of the parameter field when no further commands follow because a line feed character is automatically sent by the 9830A calculator by the end quote ("). The instruction set for the 9872A plotter is summarized in the following table.

Instruction	Definition
VECTOR GROUP	
PA x,y(,x,y(,...))	Plot absolute [i]
PR x,y (,x,y(,...))	Plot relative [i]
PD	Pen down
PU	Pen up
CHARACTER GROUP	
CA n	Designate alternate set n [i]
CP spaces, lines	Character plot [d]
CS m	Designate standard set m [i]
DI run, rise	Absolute direction [d]
DR run, rise	Relative direction [d]
LB c....c	Label ASCII string [c]
SA	Select alternate character set
SI wide, high	Absolute character size [d]
SL tan θ	Absolute character slant (from vertical) [d]
SR wide, high	Relative character size [d]
SS	Select standard character set
UC x,y,pen(,...)	User defined character [i]
LINE TYPE GROUP	
LT t(,l)	Designate line type t and length l [d]
SM c	Symbol mode [c]
SP n	Select pen [i]
VA	Adaptive velocity
VN	Normal velocity
VS v(,n)	Select velocity v for pen n [i]
DIGITIZE GROUP	
DC	Digitize clear
DP	Digitize point
OC	Output current position & pen status [i]
OD	Output digitized point & pen status [i]
AXES	
TL tp(,tn)	Tick length [d]
XT	X axis tick
YT	Y axis tick
SET-UP GROUP	
IP p1x,p1y,p2x,p2y	Input p1 and p2 [i]
IW xlo,ylo,xhi,yhi	Input window [i]
OP	Output p1 and p2 [i]
CONFIGURATION STATUS	
AP	Automatic pen pickup [i]
DF	Set default values
IM e(,s(,p))	Input e,s, and p masks [i]
IN	Initialize
OE	Output error [i]
OS	Output status [i]

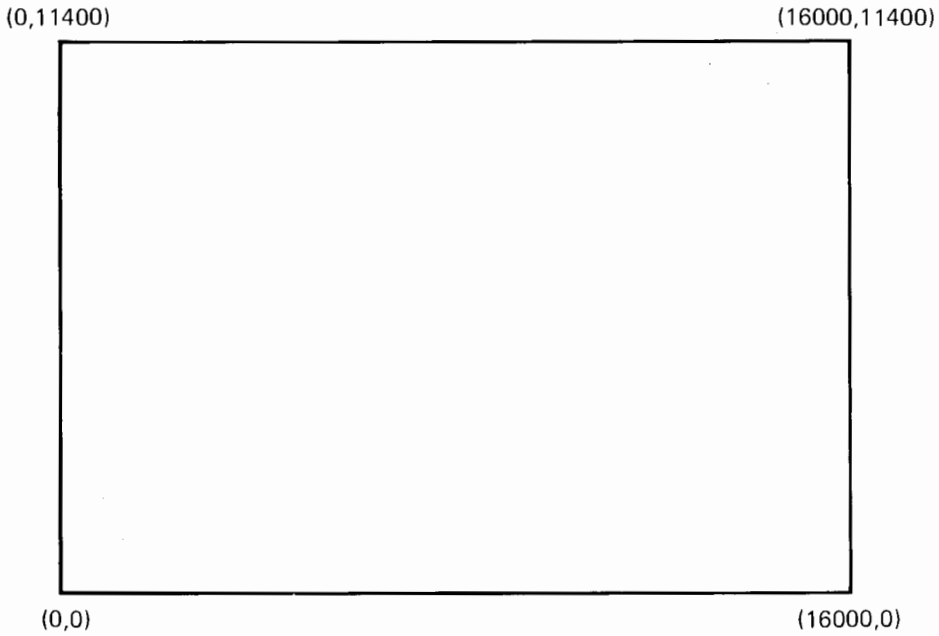
Formats: [i] = integer format between - 32768 to +32767. No decimal. [c] = ASCII character.
[d] = decimal format between ± 127.999. Decimal is optional.

Chapter 2
Plotting

This chapter describes the instructions that enable you to perform all plotting movements. Plotting moves can be made to an absolute set of coordinates, or relative to the given pen position. In addition, you can raise or lower the pen before or after the move.

The Plotter Unit

The plotting area defined on the platen is divided into plotter units where one plotter unit = 0.025 mm. The absolute plotting area is shown below:



Absolute Platen Area Scale (Mechanical Limits)

When the plotter is initialized by power-up, front panel, or use of the IN instruction, scaling points P1 and P2 are set to the points $P1_X$=520, $P1_Y$=380, $P2_X$=15720, and $P2_Y$=10380.

The Plot Absolute Instruction PA

The plot absolute instruction PA provides the means to move the pen to the point specified in plotter units by the X and Y coordinate parameters that complete the command.

Syntax:

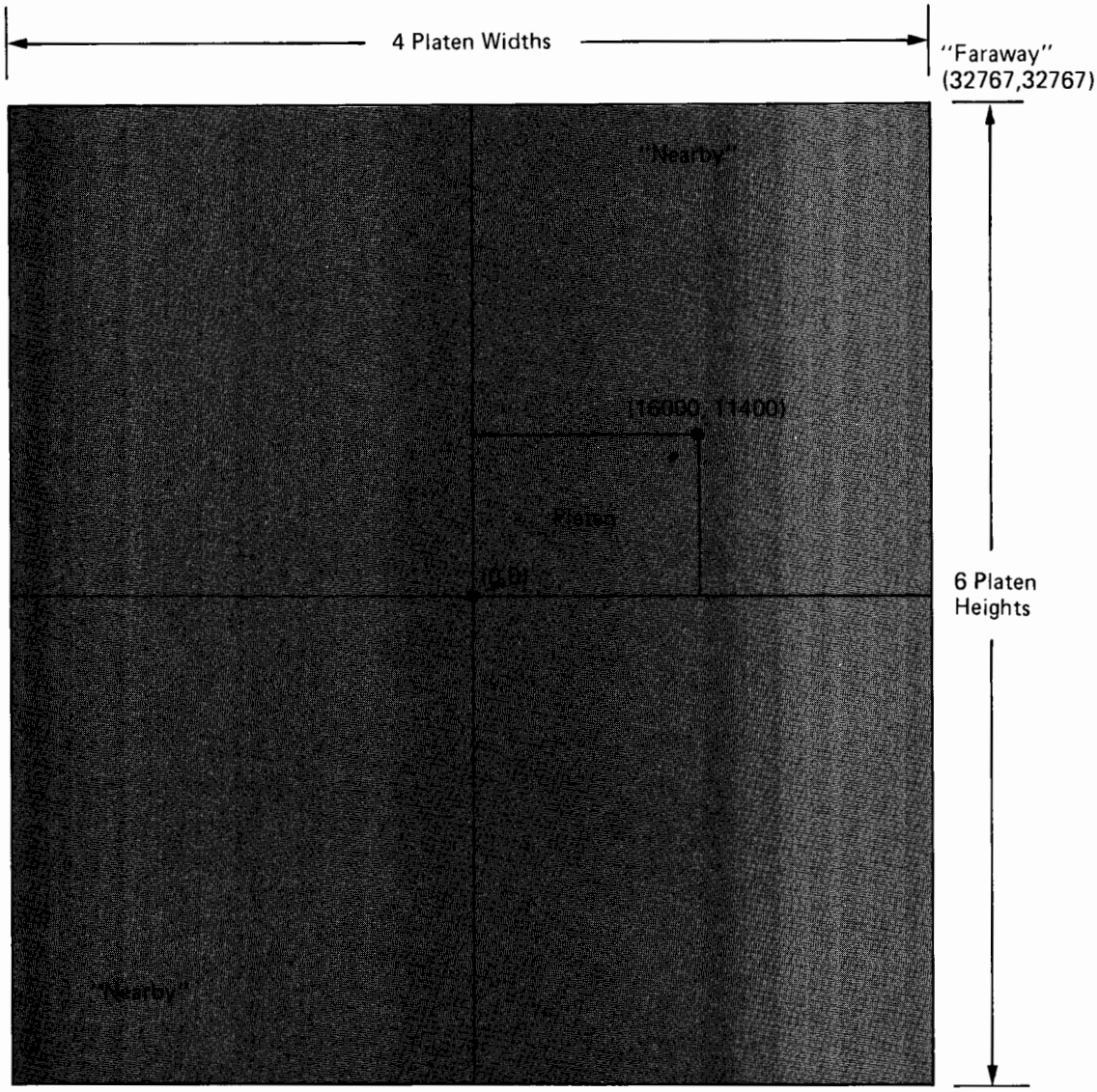
PA X_1 coordinate, Y_1 coordinate (, X_2 coordinate, Y_2 coordinate, . . . , . . . , X_n coordinate, Y_n coordinate) [; or LF]

A PA command requires that both the X and Y coordinates be specified (coordinate pair). The X coordinate parameter specifies the absolute X location in plotter units that the pen is to move to. The Y coordinate parameter specifies the absolute Y location in plotter units that the pen will move to.

Any number of coordinate pairs can be listed after the PA instruction, separated by commas. The pen will move to each point in the order given.

If the point specified by a PA command lies off the platen surface, a line is drawn to the platen limit and then the pen is raised. The pen remains raised until a point on the platen is specified.

If the point lies off the platen but is within the 'nearby' area (shown at the right), the out-of-limit light will turn on. If the point lies in the 'faraway' area, the out-of-limit light will blink.



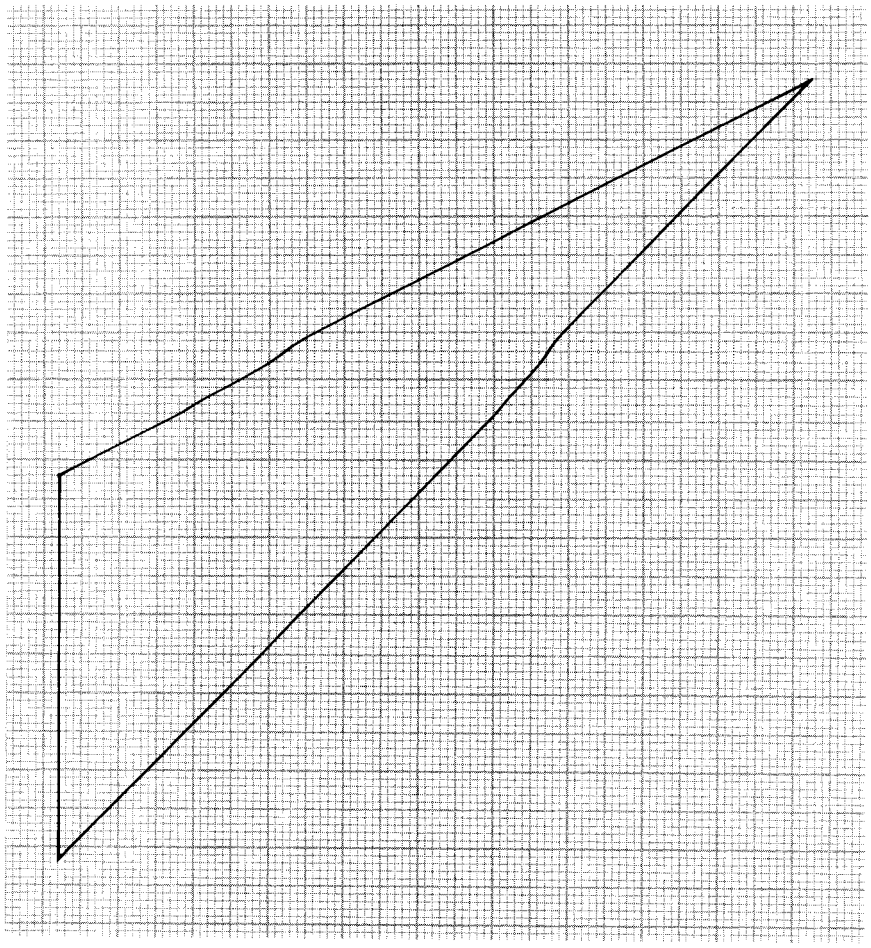
Using the PU or PD instructions, a pen control command can be placed before or after the PA command, raising (PU) or lowering (PD) the pen. If no pen control command is specified, the pen will assume the pen state (pen up or pen down) of the previous statement.

Plotting is done only within the currently defined "window" area on the platen. Refer to the Input Window Instruction IW, Chapter 6, for further information.

In-range coordinates are defined as both X and Y parameters being integer plotter units having values between -32768 and +32767.

The following example program using the 9830A causes the plotter to draw a triangle.

```
10 CMD "?U%"
20 OUTPUT (13,*)"SP1;PA1000,1000;PD;PA1000,3000"
30 OUTPUT (13,*)"PA5000,5000,1000,1000;SP0"
40 END
```



The Plot Relative Instruction PR

The plot relative instruction PR provides the means to move the pen relative to its current location by the number of plotter units specified by the X and Y parameters that complete the command.

Syntax:

PR X_1 increment, Y_1 increment, (X_2 increment, Y_2 increment, . . . , . . . , X_n increment, Y_n increment) [; or LF]

The X increment parameter specifies the number of plotter units that the pen is to move horizontally.

The Y increment parameter specifies the number of plotter units that the pen is to move vertically.

The signs of the increment parameters determine the relative direction that the pen moves in that a positive value moves the pen in a positive direction and a negative value moves the pen in a negative direction.

Any number of coordinate pairs can be listed after the PR instruction, separated by commas. The pen will move relative to the previous point in the order given.

A pen control command can be placed before or after the PR command, raising (PU) or lowering (PD) the pen. If no pen control command is specified, the pen will assume the pen state (pen up or pen down) of the previous statement.

In-range coordinates are defined as:

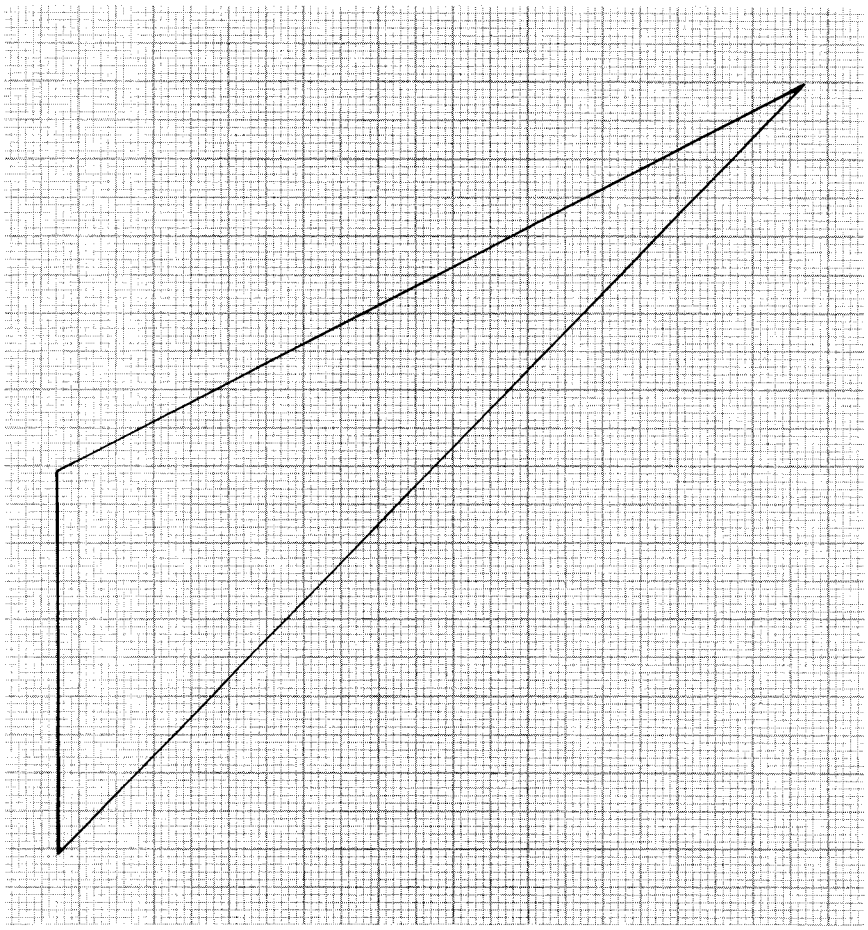
1. both X and Y parameters being integer plotter units having values between -32768 and +32767 referenced from the platen point 0,0.

2. each succeeding X and Y increment when added to the current X and Y coordinate does not exceed ±32767 plotter units when referenced from the point 0,0.

If a PR command specifies a point off the platen, the pen draws a line to the limit of the platen and stops. If the point lies off the platen in the "nearby" area as shown under the plot absolute instruction, the out-of-limit light turns on. The plotter recognizes PR commands in this area. If the point specified lies in the "faraway" area, the out-of-limit light flashes and the plotter does not recognize PR commands. A plot absolute (PA) command then must be used to specify a point that is either on the platen or in the "nearby" area before any further PR commands are recognized by the plotter.

The following example program using the 9830A causes the plotter to draw a triangle.

```
10 CMD "?U%"
20 OUTPUT (13,*)"SP1;PA1000,1000;PD;PR0,2000"
30 OUTPUT (13,*)"PR4000,2000,-4000,-4000;SP0"
40 END
```



Plotting With Variables

In most plotting applications, it is necessary to plot using variables rather than fixed numbers. The values of the X and Y variables have the same restrictions of ±32767 integer plotter units as when plotting with literals. Note that the comma with quotation marks separating the variables must be sent as part of the field. When using the 9830A calculator, a format statement defining the length of each variable must precede the plot command and must be referenced.

The following example using the 9830A illustrates the use of variables in plotting:

```
10 CMD "9U%"
15 FORMAT 2F6.0
80 FOR T=0*PI TO 2*PI STEP PI/20
90 X=500*COST+4320
100 Y=500*SINT+2880
110 OUTPUT (13,15)"PA",X,",",Y,"PD"
120 NEXT T
```

This statement defines the variable size as two integers of 6 digits each

This statement causes the plotter to move to the absolute value defined by the X and Y variables. Note the comma sent as part of the string.

The Pen Instructions PU and PD

The pen up instruction PU raises the pen without moving it to a new location. The pen down instruction PD lowers the pen without moving it to a new location.

Syntax:

PU [; or LF]

or

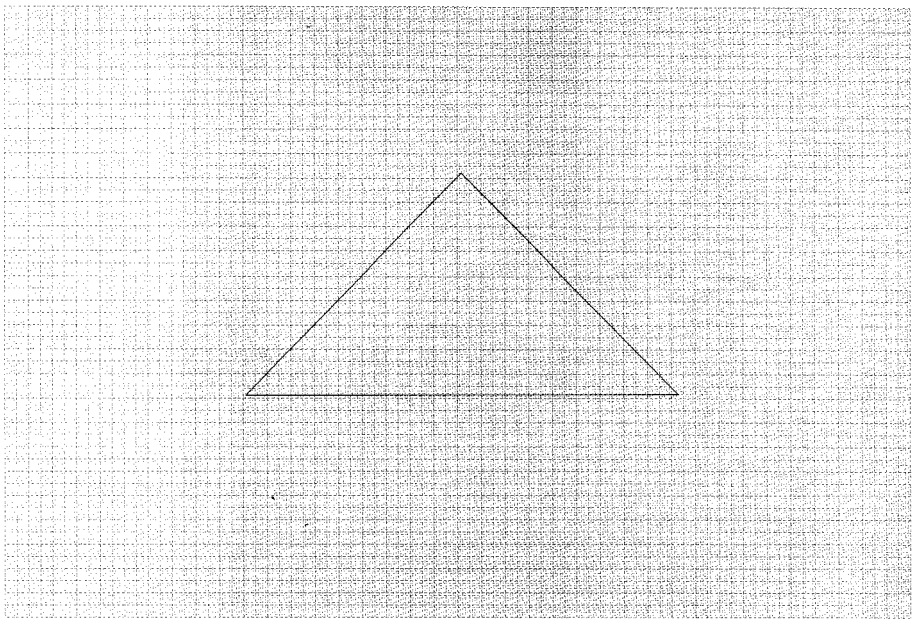
PD [; or LF]

Neither instruction requires or permits any parameters. Both instructions require the terminator ; or LF to complete the command. Front panel pushbuttons on the plotter will override these commands.

Commands to raise or lower the pen before or after movement can be included with a PA or PR command.

The following example program using the 9830A causes the plotter to draw a triangle.

```
10 CMD "9U%"
20 OUTPUT (13,*)"SP1;PA4000,4000;PD;PR4000,4000,
                 4000,-4000,-8000,0;PU;SP0"
30 END
```



Chapter 3
Lettering

This chapter describes the instructions that enable you to letter alphanumeric characters and symbols with the plotter. You can also specify the size, width, and slant of the characters as well as the direction in which characters are lettered.

The Label Instruction LB

The label instruction LB provides the means to letter text, expressions, or string variables on the plotter.

Syntax:

LB character string [ETX]

The label mode can be terminated only by sending a binary 3 (ETX) at the end of the character string. Note the 3 at the end of the character string in the examples shown below. The format statements indicate that the 3 is a binary number. Decimal characters between 0 and 32, not enclosed in quotes, cause certain control functions in the plotter. For example, decimal 13 (CR) causes a carriage return, and decimal 10 (LF) causes a line feed. When in the label mode, control functions affecting labeling, such as carriage return and line feed, must be entered before termination of the label mode. For a complete description of the control functions, refer to the plotter ASCII code definitions listed in the appendix.

Literal text is specified in a label command by enclosing it in quotes. Here is an example of text in a label command using the 9830A:

```
10 CMD "?U%"
20 FORMAT B
30 OUTPUT (13,20)"LB I AM A 9872A PLOTTER",3
40 END
```

I AM A 9872A PLOTTER

FOR HBISO PRINT #1, "LB HI THERE", CHR$(3)
terminator

In certain plotting applications, it is necessary to label using variables rather than literals. The variables are restricted in length only by the format statement which precedes the label command.

The following example using the 9830A letters with variables:

```
10 CMD "?UX"
20 FORMAT 3F3.0,B
30 X=50
40 OUTPUT (13,20)"LB"X,X+1,X+2,3
50 END
```

This statement defines the variable size as three integers of three digits (including sign) each. The B indicates that the last character sent will be a binary 3 (ETX) causing the plotter to exit the label mode.

In this statement, the plotter labels the integer, integer + 1, and integer + 2. The single space between the integers is the sign space and since it is positive, it is not printed.

```
50 51 52
```

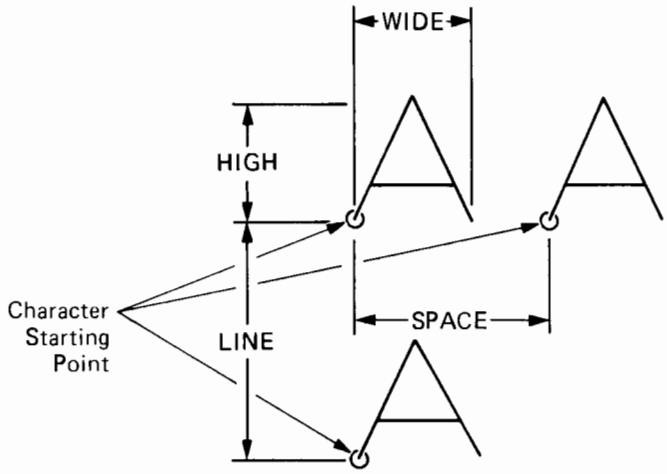
Any spaces required to fit into the context of the item being lettered must be sent enclosed in quotes. The following example letters the same variables as above, but with four spaces between each of the values plus the sign space.

```
10 CMD "?UX"
20 FORMAT 3F3.0,B
30 X=50
40 OUTPUT (13,20)"LB"X"    "X+1"    "X+2,3
50 END
```

Note that four spaces enclosed in quotes are sent between each variable.

```
50      51      52
```

Before using a label command, the pen should be moved to the location where labeling is to begin by using one of the plot commands (PA, PR, CP) or by using the four direction controls on the plotter front panel. This point will be the lower-left corner of the first character. After lettering a character, the pen stops at the lower-left corner of the next character space as shown below. For a further explanation of character spacing, refer to Spacing Between Characters and the Character Grid, Chapter 3.



Direction, size, and slant of the characters being lettered are as previously specified by the commands using DI, DR, SI, SR, and SL, or default values if not specified. The character set used is specified by the commands using SA or SS, and CA or CS. If not specified, the default character set is set 0.

The Absolute Direction Instruction DI

The absolute direction instruction DI provides the means to specify the direction in which characters are lettered.

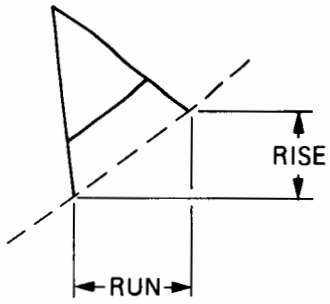
Syntax:

DI run, rise [; or LF]

Run and rise are in decimal format between ±127.999 and specify the direction according to the relationship:

$$\frac{\text{rise}}{\text{run}}$$

where

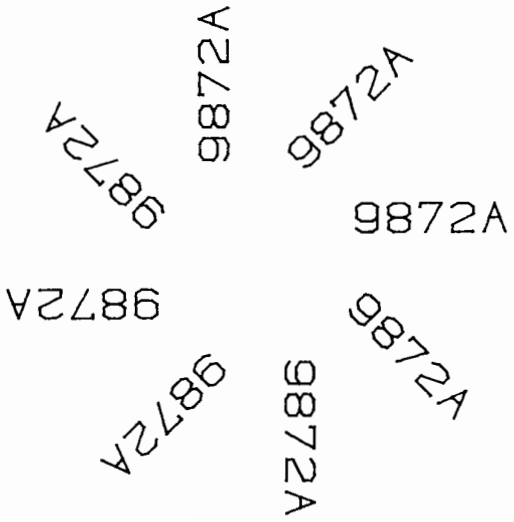


A change of scale points P1 and P2 will not affect the direction of lettering.

A DI command with no parameters (DI;) will default to the values DI 1,0 (horizontal).

The following example, using the 9830A, letters the word 9872A in a clockwise direction at each 45° point:

```
10 FORMAT B
20 CMD "?U%"
30 OUTPUT (13,10)"SP1;DI0,1;LB 9872A",13,3
40 OUTPUT (13,10)"DI1,1;LB 9872A",13,3
50 OUTPUT (13,10)"DI1,0;LB 9872A",13,3
60 OUTPUT (13,10)"DI1,-1;LB 9872A",13,3
70 OUTPUT (13,10)"DI0,-1;LB 9872A",13,3
80 OUTPUT (13,10)"DI-1,-1;LB 9872A",13,3
90 OUTPUT (13,10)"DI-1,0;LB 9872A",13,3
100 OUTPUT (13,10)"DI-1,1;LB 9872A",13,3"SP0"
110 END
```



The Relative Direction Instruction DR

The relative direction instruction DR provides the means to specify the direction in which characters are to be lettered relative to the scaling points P1 and P2.

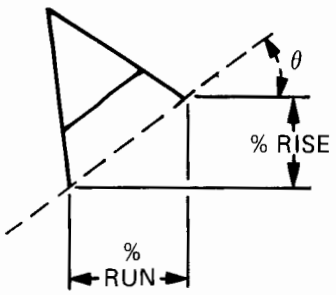
Syntax:

DR % run, % rise [; or LF]

Run and rise can be any units and specify the direction according to the relationship:

$$\frac{\%\ \text{rise}}{\%\ \text{run}}$$

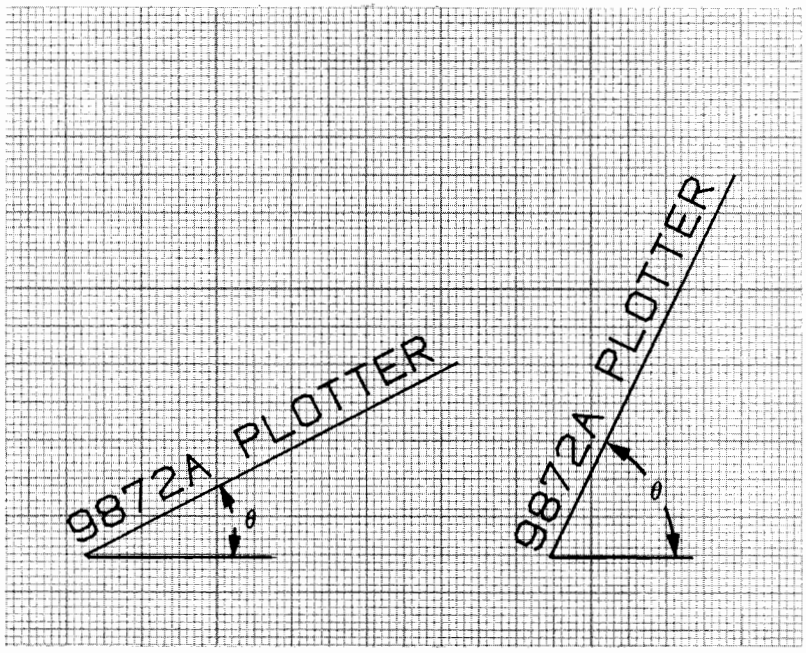
where:



% run is the desired percentage (0 to ±127.999) of $|P2_X - P1_X|$, % rise is the desired percentage (0 to ±127.999) of $|P2_Y - P1_Y|$, and P1 and P2 are the scaling points.

Note in the following example using the 9830A that even though a DR 100,100 is chosen for each set of scaling points P1 and P2, since angle θ has changed with a change in scaling points, the direction of lettering changes also.

```
10 FORMAT B
20 CMD "?U%"
30 OUTPUT (13,*)"SP1;IP1000,1000,3000,2000"
40 OUTPUT (13,*)"PA1000,1000;PD;PA3000,2000;PU"
45 OUTPUT (13,*)"PA1000,1000;DR100,100;SI;CP0,.25"
50 OUTPUT (13,10)"LB9872A PLOTTER",3
60 OUTPUT (13,*)"IP3500,1000,4500,3000"
65 OUTPUT (13,*)"PA3500,1000;PD;PA4500,3000;PU"
70 OUTPUT (13,*)"PA3500,1000;DR100,100;CP0,.25"
80 OUTPUT (13,10)"LB9872A PLOTTER",3,"SP0"
90 END
```

The Absolute Character Size Instruction SI

The absolute character size instruction SI provides the means to specify the size of characters and symbols in centimeters.

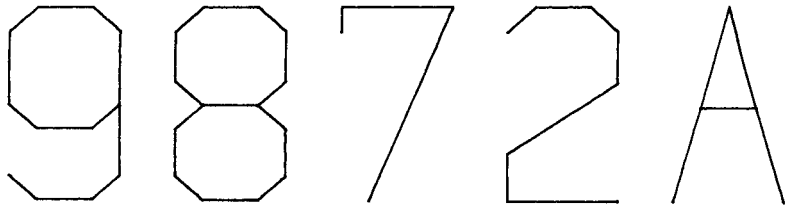
Syntax:

SI width, height [; or LF]

The defined width and height must be in decimal format and may have any value between 0 and +127.999. Although the SI command specifies the width and height in centimeters, due to the chosen conversion factor (2.5 cm = 1 in.), the actual character size will be 98.1% of specified size. An SI command with no parameters (SI;) will default to the values 0.285 cm wide by 0.375 cm high.

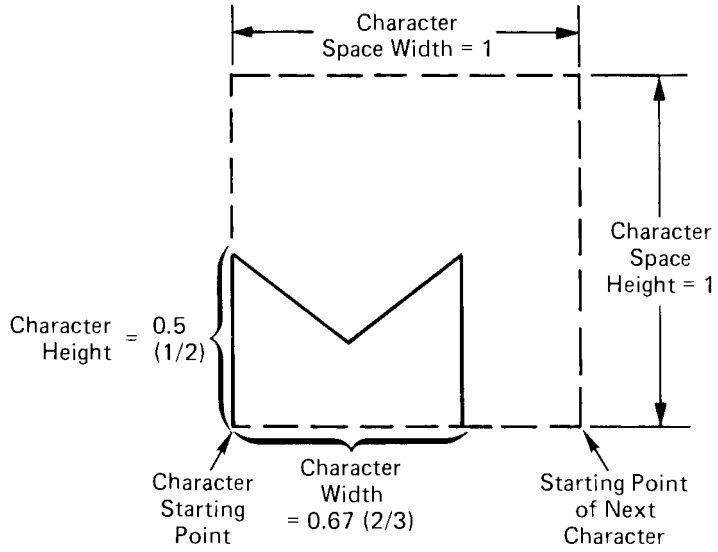
The following example using the 9830A letters the word 9872A at a specified width of 1.5 cm and height of 2.5 cm.

```
10 FORMAT B
20 CMD "?U%"
30 OUTPUT (13,10)"SP1;SI1.5,2.5;LB 9872A",3"SP0"
40 END
```



Spacing Between Characters and the Character Grid

Character spacing and line spacing are functions of character size. In the diagram below, you can see the relative position of a character, in this case M, within the character-space field. The character-space field is set indirectly by the SI command, since the character space height is twice the character's height and the character space width is 1-1/2 times the character width. The space above and beside a character becomes the spacing between lines and characters.



When you specify the height of a character in an SI or SR command, however, you should specify the character height and not the height of the character-space field.

The Relative Character Size Instruction SR

The relative character size instruction SR provides the means to specify the size of characters and symbols as a percentage of the distance between scaling points P1 and P2.

Syntax:

SR % width, % height [; or LF]

The % width is the desired percentage (0 to +127.999) of $|P2_X - P1_X|$, % height is the desired percentage (0 to +127.999) of $|P2_Y - P1_Y|$, and P1 and P2 are the scaling points.

Note that character size will vary as P1 and P2 are changed. Character and line spacing are functions of character size. Refer to Spacing Between Characters, Chapter 3.

An SR command with no parameters (SR;) will default to the same values as SR .75, 1.5.

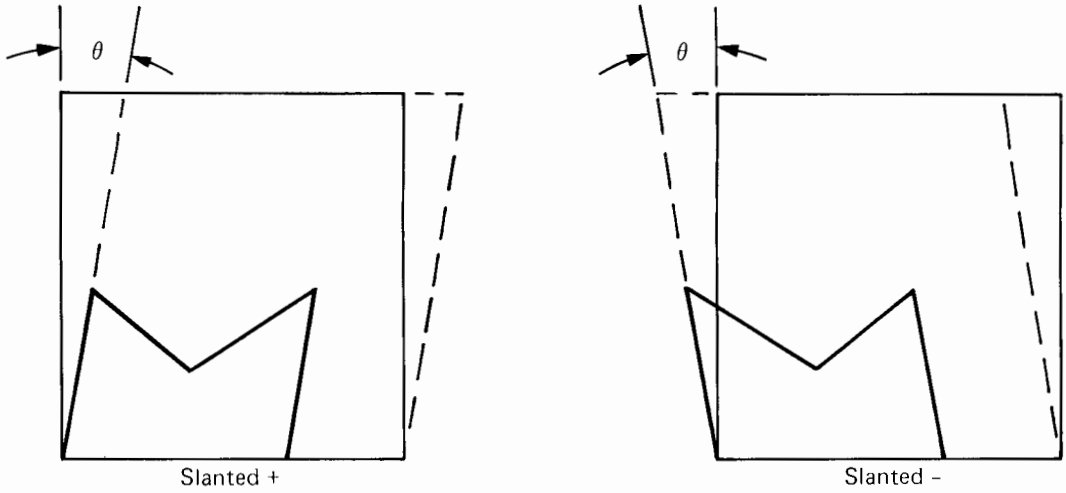
The Character Slant Instruction SL

The character slant instruction SL provides the means to specify the slant with which characters are lettered.

Syntax:

SL decimal number [; or LF]

The degree of slant is a decimal number between ±127.999 and is equivalent to the tangent of the angle θ from vertical as follows:



A change in scaling points P1 and P2 will not affect the angle θ.

An SL command with no parameters (SL;) will default to the same values as SL0 (no slant).

The following example using the 9830A letters the word 9872A at a slant of +45°.

```
10 FORMAT B
20 CMD "?U%"
30 OUTPUT (13,10)"SP1;SL1;LB 9872A",3"SP0"
40 END
```

9872A

The Character Plot Instruction CP

The character plot instruction CP provides the means to move the pen the specified number of character-space fields.

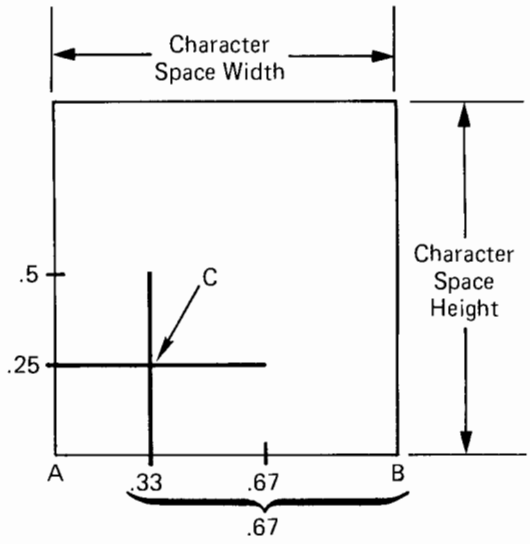
Syntax:

CP # of character-space widths, # of character-space heights [; or LF]

If no parameters are specified, a CP command (CP;) performs a carriage return and line feed operation by moving one character-space height down and returning to the margin defined by the last point that the pen was sent to by either a PA command, PR command, or the plotter front-panel controls. If an SI or SR command is executed after the pen is positioned by a PA, PR, or the front panel controls, the location of the pen when the SI or SR command is executed becomes the margin that the pen returns to when a CP is executed without parameters.

When parameters are specified, the CP command moves the pen the specified number of character-space widths to the right (a positive value) or to the left (a negative value) and the number of character-space heights up (a positive value) or down (a negative value). The pen's position (raised or lowered) does not change when a CP command is executed. The parameters must be within the range of ±127.999.

Character plot may be used to label each plotted point on a graph with a +. The following diagram shows the spacing around the symbol +. Note that the pen begins to draw at point A, and ends at point B, ready to draw another character.



To center the symbol on point C, which represents a plotted point, the pen must be moved to point A. This can be done using the CP instruction by specifying the parameters -.33, -.25. After the symbol is drawn, the pen must be returned from point B to point C to continue plotting the next point. This can be done using the CP instruction by specifying the parameters -.67, .25.

Chapter 4
Graph Enhancement

This chapter describes the instructions that enable you to enhance the plotted data with such things as axes with tick marks, pen selection for multicolor plotting, and special symbols.

The Tick Instructions XT and YT

The tick instruction XT provides the means to draw a vertical X tick at the current pen location. The tick instruction YT provides the means to draw a horizontal Y tick at the current pen location.

Syntax:

XT [; or LF]

or

YT [; or LF]

Neither instruction requires any parameters. Both instructions require the terminator ; or LF to complete the command.

The tick length is specified by the tick length command using TL. If no tick length is specified, the default length is 0.5% of $|P2_X - P1_X|$ or $|P2_Y - P1_Y|$.

The following example, using the 9830A, draws a horizontal line, 15000 plotter units long, and places X ticks at the end points and at 5000 and 10000 plotter unit points:

```
10 CMD "?U%"
20 OUTPUT (13,*)"PA1000,5000;PD;XT;PR5000,0;XT
30 OUTPUT (13,*)"PR5000,0;XT;PR5000,0;XT;PU"
40 END
```

The Tick Length Instruction TL

The tick length instruction TL provides the means to specify the length of the tick marks drawn by the plotter. The tick lengths are specified as a percentage of the horizontal and vertical distances between the scaling points P1 and P2.

Syntax:

TL tp, tn [; or LF]

The up and right tick length tp determines the length of the upward portion of the tick marks drawn along the X axis and the right-side portion of the tick marks drawn along the Y axis. This value is specified as a percentage of the vertical scale length, $|Y_{P2} - Y_{P1}|$.

The down and left tick length tn determines the length of the downward portions of the tick marks drawn down along the X axis and the left-side portion of the tick marks drawn along the Y axis. The value is specified as a percentage of the horizontal scale length $|X_{P2} - X_{P1}|$.

The plotter, when initialized, automatically sets the tick length values to 0.5% of the scaling lengths ($|Y_{P1} - Y_{P1}|$ and $|X_{P2} - X_{P1}|$). A TL command with no parameters (TL;) will default to the same values.

The following example, using the 9830A, draws a 10 X 10 grid on the plotter defined within the points P1=520, 380 and P2=15720, 10380. Note that only the up and right tick length parameter is specified since only the area above the X axis and to the right of the Y axis is being used.

```
10 CMD "?U%"
20 OUTPUT (13,*)"SP1;PA520,380;TL100;XT"
30 FOR I=1 TO 10
40 OUTPUT (13,*)"PR1520,0;XT"
50 NEXT I
60 OUTPUT (13,*)"PA520,380;YT"
70 FOR J=1 TO 10
80 OUTPUT (13,*)"PR0,1000;YT"
90 NEXT J
100 OUTPUT (13,*)"SP0"
110 END
```

Tick Length Example

The Pen Select Instruction SP

The pen select instruction SP provides the means to select a pen through program control.

Syntax:

SP pen position number [; or LF]

The pen position number must be an integer in the range of 0 through 4. When command SP is executed, the pen arm raises the pen it is currently holding (if any) and returns it to the position from which it was originally fetched. The new pen designated by the SP command is then fetched and the pen arm returns to its last position prior to the SP command.

A pen position number of 0 or no parameter directs the pen arm to return the pen it is currently holding to its stall then the pen arm returns to its last position prior to the SP command.

If the specified pen position is empty, or if all of the pen positions are full and there is a pen in the arm, then no operation occurs.

If the position from which the pen was originally fetched has since become occupied, the currently held pen is placed in the lowest numbered vacant stall.

Plotter front panel pen select controls can override the program command.

The Symbol Mode Instruction SM

The symbol mode instruction SM is used with PA and PR commands and provides the means to draw a symbol at the end of each vector.

Syntax:

SM character [; or LF]

The character is limited to one of the centered characters of the character set chosen.

The PA or PR commands function as described in Chapter 2, except that the specified character is drawn at the end of each vector, centered on the plotted point. The character will be drawn at the end of the vector whether the pen is up or down.

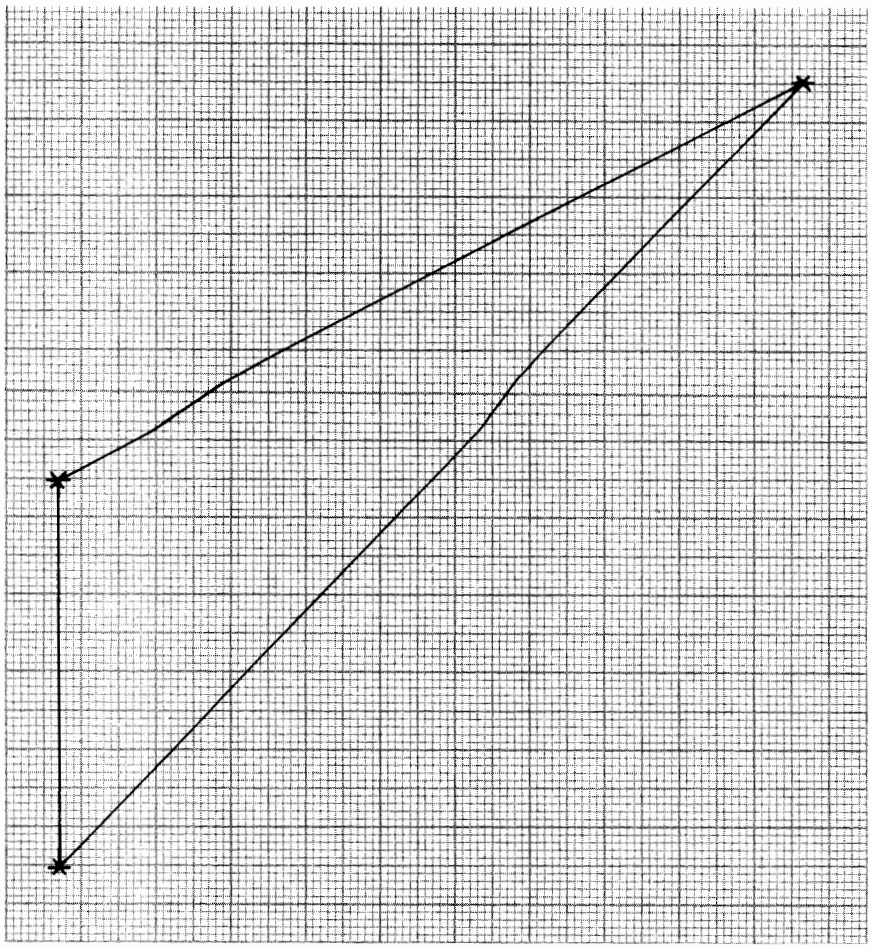
The character is drawn according to the currently selected character set. Once selected, the character is independent of character set changes later in the program and can only be changed by a new SM command. If a character is not specified (SM;) the symbol mode is cancelled. The size (SI and SR), slant (SL), and direction (DI and DR) commands affect the character drawn.

All ASCII characters from decimal 31 through 127 can be specified except for the following:

ASCII Character	Decimal Value	ASCII Character	Decimal Value
!	33	?	63
"	34	@	64
%	37	[	91
&	38	\	92
'	39	]	93
(	40	^	94
)	41	_	95
/	47	`	96
:	58	{	123
;	59	|	124
<	60	}	125
=	61	~	126
>	62		

The following program, using the 9830A, causes the plotter to draw a triangle with the symbol * drawn at each apex.

```
10 CMD "?U%"
20 OUTPUT (13,*)"SP1;PA1000,1000;PD;SM*;PA1000,3000"
30 OUTPUT (13,*)"PA5000,5000,1000,1000;SP0"
40 END
```



The Line Type Instruction LT

The line type instruction LT provides the means to specify the type of line that will be used with PA and PR commands.

Syntax:

LT pattern number, pattern length [; or LF]

Shown below are the line patterns and their pattern numbers.

0- specifies dots only at the points that are plotted.

1-

2-

3-

4-

5-

6-

No parameter (Default Value)

The shaded portion of each of the line patterns above is one complete segment of the pattern.

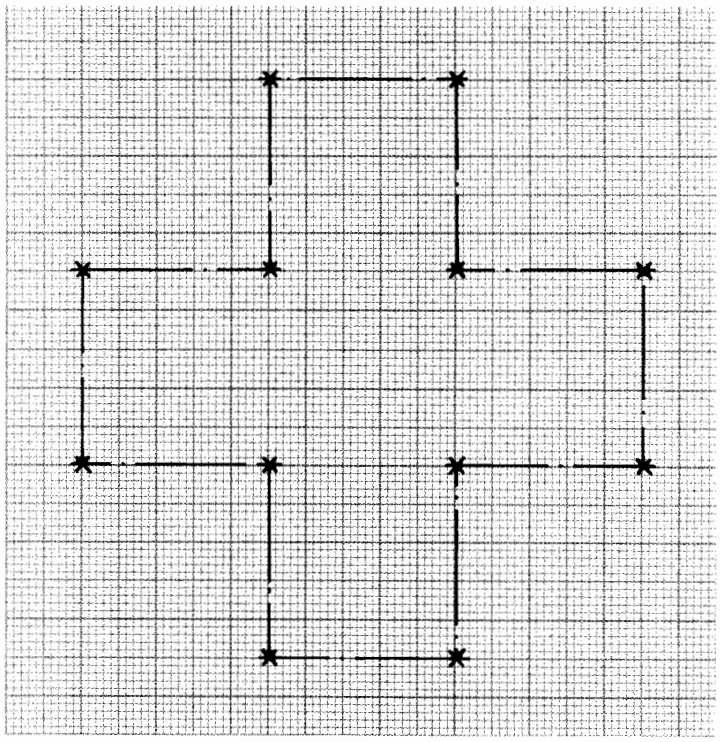
The optional pattern length parameter specifies the length of one complete segment of the pattern and is expressed as a percentage of the diagonal distance between the scaling points, P1 and P2. If a pattern length parameter is not specified, a length of 4% is used. The range of the pattern length parameter is from 0 thru 127.999.

After this command, all subsequent vector commands with the pen down will cause the specified pattern to be drawn. Any portion of the pattern which is not used will be carried over into the next vector.

An LT command with no parameters (LT;) will default the line type to a solid line.

The following example, using the 9830A, plots a cross using line type 4, and draws the symbol * at each corner point.

```
10 CMD "?U%"
20 OUTPUT (13,*)"SP1;PA5000,5000;PD;LT4;SM*;PR1000,0,0,1000"
30 OUTPUT (13,*)"PR1000,0,0,-1000,1000,0,0,-1000,-1000,0"
40 OUTPUT (13,*)"PR0,-1000,-1000,0,0,1000,-1000,0,0,1000;SP0"
50 END
```



Chapter 5
Digitizing

The Digitize Point Instruction DP

The digitize point instruction DP provides the means to digitize points on the plotter.

Syntax:

DP [; or LF]

No parameters are used, however the terminator ; or LF must be included to complete the command.

When command DP is sent, the ENTER light turns on indicating that a point can be entered. When the ENTER pushbutton is pressed, the X and Y coordinates of that point and pen up/down status are stored for retrieval by the OD command. Pressing the ENTER pushbutton also turns off the ENTER light.

The Digitize Clear Instruction DC

The digitize clear instruction DC provides the means to terminate the digitize mode.

Syntax:

DC [; or LF]

No parameters are used, however the terminator ; or LF must be included to complete the command.

This command enables you to terminate a digitize mode without entering coordinate values through the ENTER pushbutton. The ENTER light is turned off (if it was on).

The Output Digitized Point and Pen Status Instruction OD

The output digitized point and pen status instruction OD provides the means to make the X and Y coordinates and pen status (up or down) associated with the last digitized point available for output.

Syntax:

OD [; or LF]

No parameters are used, however the terminator ; or LF must be included to complete the command.

The OD command is used when in the digitize mode after receipt of the output status byte with a true (1) condition on bit position 2 (see Output Status Instruction, Chapter 6).

To ensure data transfer from the plotter to the controller, the plotter must be instructed to talk and the controller to listen. The pen position and status will be outputted to the controller in ASCII as follows:

X Y P CR LF

where X is the X coordinate in absolute plotter units
Y is the Y coordinate in absolute plotter units
P is the pen status (0 = pen up, 1 = pen down).

The range of the X and Y coordinates is ±32767. The plotter will output a negative sign for negative numbers; positive signs are suppressed.

Upon receipt of the OD command by the plotter, bit position 2 of the output status byte is cleared, and the ENTER light is turned off (if it was on).

The Output Current Position and Pen Status Instruction OC

The output current position and pen status instruction OC provides the means to make the X and Y coordinates and pen status (up or down) associated with the last valid pen position instruction available for output.

Syntax:

OC [; or LF]

No parameters are used, however the terminator ; or LF must be included to complete the command.

The OC command can be used in any mode (use OD when digitize mode).

To ensure data transfer from the plotter to the controller, the plotter must be instructed to talk and the controller to listen. The pen position and status will be outputted to the controller in ASCII as follows:

X Y P CR LF

where X is the X coordinate in absolute plotter units
Y is the Y coordinate in absolute plotter units
P is the pen status (0 = pen up, 1 = pen down).

The range of the X and Y coordinates is ±32767. The plotter will output a negative sign for negative numbers; positive signs are suppressed.

Digitizing With the 9872A

The plotter can be used as a digitizer as well as a plotter since digitizing is basically the inverse of plotting. Instead of sending the coordinates of a point to the plotter and the plotter then moving the pen to that point, you move the pen to a point on the plotter (typically by using the front panel controls), enter the point, then send the coordinates of that point to the controller. A special digitizing sight is provided with the plotter which allows you to visually position the pen over the point to be digitized. The sight is loaded and stored like a pen.

In general, the DP command is used with the OS and OD commands. The output status command OS is explained in Chapter 6. A generalized program flow for the digitize mode is listed below.

1. Allocate in memory the number of points to be digitized for the variables X, Y, and P.

2. Dimension a string variable to be used for binary conversion of the pen status byte (8 bits).

3. Develop a FOR-NEXT loop with the total number of points digitized.

4. Enter the digitize mode, output the pen status byte, and monitor bit position 2 of the pen status byte for a true (1) condition. The true condition indicates that the ENTER pushbutton has been pressed.

5. Output the digitized point to the controller.

6. Continue the loop for all digitized points then print the values for each digitized point if desired.

The following example program using the 9830A enables you to digitize four points. At each point, you press the ENTER pushbutton to send the coordinates of that point to the controller.

```
10 CMD "?U%"
20 X=Y=P=S=0
30 DIM X[4],Y[4],P[4],A$[8]
40 FOR D=1 TO 4
50 OUTPUT (13,*)"DP"
60 PRINT "ENTER THE POINT PLEASE."
70 GOSUB 500
80 CMD "?E5"
90 ENTER (13,*)X[D],Y[D],P[D]
100 CMD "?U%"
110 NEXT D
120 FOR L=1 TO 4
130 PRINT X[L],Y[L],P[L]
140 NEXT L
150 END
500 OUTPUT (13,*)"OS"
510 CMD "?E5"
520 ENTER (13,*)S
530 CMD "?U%"
540 B=1
550 FOR N=7 TO 0 STEP -1
560 IF S/(2↑(N)) >= 1 THEN 590
570 A$[B,B]="0"
580 GOTO 610
590 A$[B,B]="1"
600 S=S-2↑N
610 B=B+1
620 NEXT N
630 IF A$[6,6]="1" THEN 650
640 GOTO 500
650 OUTPUT (13,*)"OD"
660 RETURN
```

This portion of the program establishes the number of points to be measured and dimensions the string variable.

This portion of the program causes the plotter to output the data points to the controller by first instructing the plotter to talk and the controller to listen then outputting the data.

This portion of the program ensures that the ENTER pushbutton is pressed before continuing program execution.

Chapter 6
Additional Plotter Control

In addition to the instructions described in the previous chapters, the plotter has additional capabilities grouped as follows:

Pen Control Instructions

Automatic Pen Pickup AP
Set Adaptive Pen Velocity VA
Set Normal Pen Velocity VN
Select Pen Velocity VS

Character Control Instructions

Designate Standard Character Set CS
Designate Alternate Character Set CA
Select Standard Character Set SS
Select Alternate Character Set SA
User Defined Character UC

Plotter Configuration and Status Instructions

Input Mask IM
Input Window IW
Default DF
Initialize IN
Output Error OE
Output Status OS

External Plotter Commands

Device Clear
Serial Polling
Parallel Polling

Pen Control Instructions

The Automatic Pen Pickup Instruction AP

The automatic pen pickup instruction AP causes the plotter to automatically raise the pen whenever it has been down without motion for 65 seconds.

Syntax:

AP [; or LF]

No parameters are used, however the terminator ; or LF must be included to complete the command.

The automatic pen pickup is set when the plotter is initialized and can be disabled by sending the characters AP0.

The Adaptive Pen Velocity Instruction VA

The adaptive pen velocity instruction VA provides the means to adapt the pen speed, automatically, to approximate the rate that the controller sends coordinate data to the plotter.

Syntax:

VA [; or LF]

No parameters are used, however the terminator ; or LF must be included to complete the command.

This mode provides a smoother plot than the normal velocity mode when plotting coordinates that are generated by a relatively slow program routine (fewer than 15 coordinates/s). The maximum pen speed will not exceed the speed selected by the previous VS command. The minimum pen speed is approximately 0.4 cm/s.

If the time required to complete a plot is a consideration, care should be taken in writing a program with the VA command. The plotter will automatically slow down to the controller data rate. Therefore, if the controller outputs a group of data points very slowly, the plotter will adapt to this speed and begin making very slow movements. Should the controller then begin long vector, higher speed data, it will take a few data points before the plotter is again up to the data speed which may not be desirable.

The Normal Velocity Instruction VN

The normal velocity instruction VN provides the means to cancel the adaptive velocity mode.

Syntax:

VN [; or LF]

No parameters are used, however the terminator ; or LF must be included to complete the command.

After receipt of a VN command, the pen speed is then controlled by the current pen velocity command.

The Velocity Select Instruction VS

The velocity select instruction VS provides the means to specify the pen speed, in centimeters per second, for plotting and lettering operations.

Syntax:

VS pen velocity (, pen number) [; or LF]

The pen velocity can be any integer between 1 and 36 cm/s. If the optional pen number (an integer, 1 to 4) is specified, the speed will apply only to that pen. If a pen number is not specified, the speed applies to all pens.

When the plotter is initialized, the pen velocity is defaulted to a value of 36 cm/s. A command VS with no parameters (VS;) also defaults the pen velocity.

Character Control Instructions

Character Sets

The plotter has the capability of lettering with any of five designatable character sets. Each of the five character sets has identical characters with the exception of certain symbols. The plotter, when initialized, automatically sets both the "standard" set and "alternate" set to the ANSI ASCII character set (Set 0), which follows:

CHARACTER SET Ø

```
 ! "#$%&' ()*+,-./Ø123456789:;<=>?
@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^
_`abcdefghijklmnopqrstuvwxyz{¦}~
```

Shown next are the symbols in the various character sets that are changed from set to set. The plotter will perform an automatic backspace when drawing any of the shaded symbols.

Decimal Value	Set Ø	SeT 1	Set 2	Set 3	Set 4
35	#	#	£	£	¿
39	´	'	´	´	´
91	[	[	[	Ø	[
92	\	ƒ	ç	Æ	¡
93	]	]	]	ø	]
94	^	↑	^	æ	^
95	_	_	_	_	_
96	`	~	`	`	`
123	{	π	¨	¨	~
124	¦	⊢	°	°	~
125	}	→	¨	¨	~
126	~	~	'	°	~

The Designate Standard Character Set Instruction CS

The designate standard character set instruction CS provides the means of selecting one of the five character sets (0 thru 4) as the standard character set.

Syntax:

CS 0 thru 4 [; or LF]

The character set selected is used for all labeling and lettering operations when the standard set is specified. Character set 0 is automatically set whenever the plotter is initialized.

A command CS with no parameters (CS;) defaults to set 0.

The Designate Alternate Character Set Instruction CA

The designate alternate character set instruction CA provides the means of selecting one of the five character sets (0 thru 4) as the alternate character set.

Syntax:

CA 0 thru 4 [; or LF]

The character set selected is used for all labeling and lettering operations when the alternate character set is specified.

Any of the five character sets (0 thru 4) can be specified. Character set 0 is automatically specified as the alternate character set whenever the plotter is initialized.

A command CA with no parameters (CA;) defaults to set 0.

The Select Standard Set Instruction SS

The select standard set instruction SS provides the means of selecting the standard set as the character set to be used for all labeling.

Syntax:

SS [; or LF]

No parameters are used, however the terminator ; or LF must be included to complete the command.

This command is automatically selected when the plotter is first turned on or initialized. The standard set can be selected within a label command by sending the ASCII control character for shift-in (decimal 15).

The Select Alternate Set Instruction SA

The select alternate set instruction SA provides the means of selecting the alternate set as the character set to be used for all labeling.

Syntax:

SA [; or LF]

No parameters are used, however the terminator ; or LF must be included to complete the command.

This command should be executed prior to executing a labeling statement whenever the alternate character set is to be used. The alternate set can be selected within a label command by sending the ASCII control character for shift-out (decimal 14).

The User Defined Character Instruction UC

The user defined character instruction UC provides the means to draw characters of your own design.

Syntax:

UC (pen control parameter,) X increment, Y increment,
(pen control parameter,) (X increment, Y increment,)
. . . . . [; or LF]

Each segment of the character is drawn according to the three parameter values as follows:

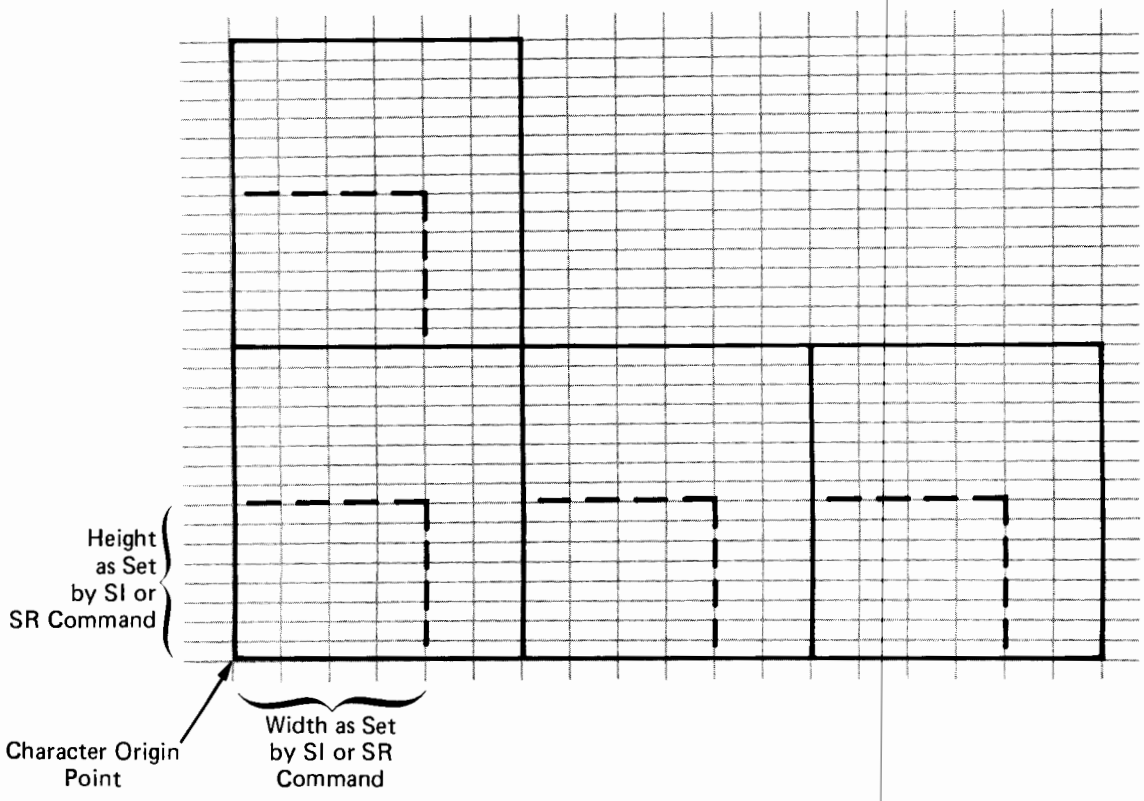
Pen control parameter (integer) +99 = pen down and - 99 = pen up.

X increment – specifies the number of character grid units that the pen will move horizontally. A positive value moves the pen to the right, and a negative value moves it to the left. The increment value must be an integer and can range from -98 thru +98 grid units.

Y increment – specifies the number of character gird units that the pen will move vertically. A positive value moves the pen up and a negative value moves it down. The increment value must be an integer and can range from -98 thru +98 grid units.

The optional pen control parameter does not have to be repeated between X and Y increments unless a different pen state is required. That is, once a pen down (+99) has been sent, the pen will remain down for the following X and Y increments until a pen up (-99) has been sent.

The character grid units are scaled by the current size command (SI or SR) as shown below. Each character block contains 6 horizontal units and 16 vertical units.



Note that the character block width is 1-1/2 times the character width as set by the size command and twice the character height as set by the size command.

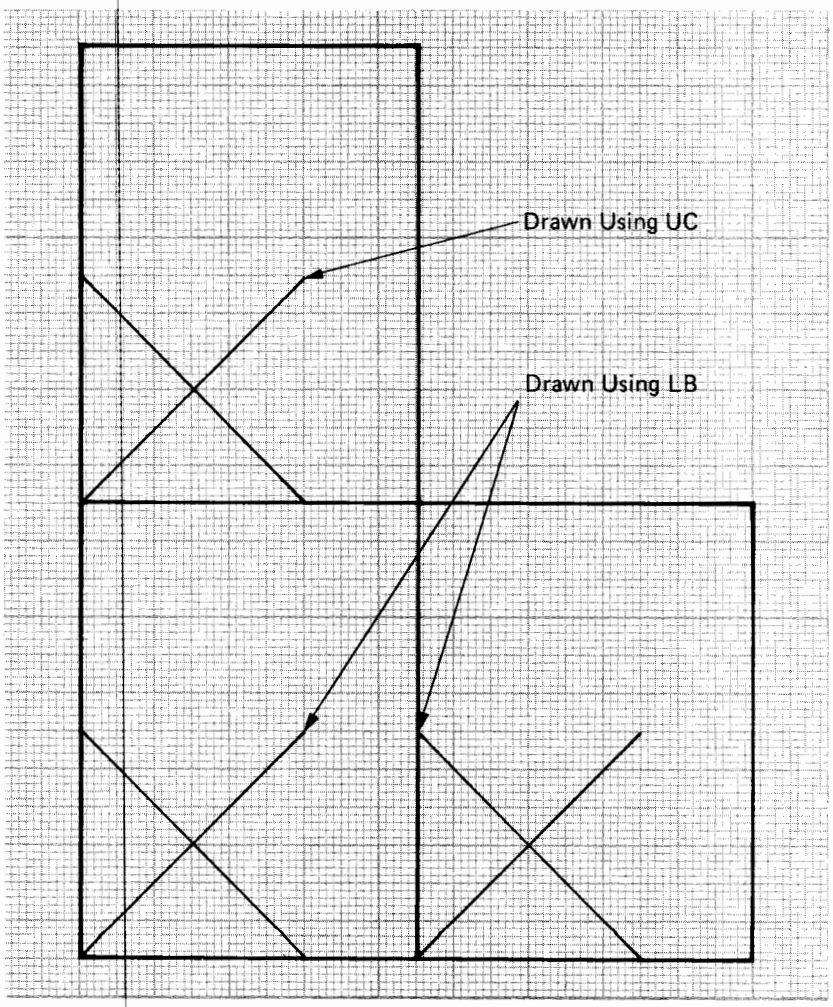
Each character starts from the character block origin point. When the character is completed, the pen moves to the next character-block's origin (6 grid units from the initial starting point). This may not be a valid starting point if the new character was larger than a normal character. One of the plot commands (PA, PR, or CP) may be needed to properly position the pen for the next character, if any, to be lettered.

A user defined character is drawn with the current character slant, size, and direction.

It is recommended that the pen up parameter (-99) be given at the conclusion of the UC group. Although the pen will lift before moving to the next character block origin, if pen up (-99) is not stated, moves following UC, such as PA, PR, or CP, will be made with the pen down.

The following example program using the 9830A, uses the UC command to draw an X at a character size of 3 x 3 cm. To demonstrate the comparison in size between characters drawn using the UC command and LB command, two X's are then drawn using the LB command. Note that in order to draw a character using the UC command the same size as a character using the LB command, the UC command uses a width of 4 grid units by a height of 8 grid units.

```
10 FORMAT B
15 FORMAT 3B
20 CMD "?U%"
30 OUTPUT (13,15)"SI3,3;UC99,4,8,-99,-4,0,99,4,-8,-99;LB"
          ,13,10,3
40 OUTPUT (13,10)"LBXX",3
50 END
```



Plotter Configuration and Status Instructions

The Input Mask Instruction IM

The input mask instruction IM provides the means to specify the conditions under which an error message, require service message, and parallel poll response will occur.

Syntax:

IM E-mask value, S-mask value, P-mask value [; or LF]

E-mask specifies the decimal equivalent of the bit values of the plotter error numbers that will set the error bit (bit 5) of the plotter status byte and turn on the error light on the plotter front panel.

E-Mask Bit Value	Error Number	Meaning
1	1	Instruction not recognized
2	2	Wrong number of parameters
4	3	Bad parameters received
8	4	Illegal character
16	5	Unknown character set
32	6	Position overflow
64	7	Not used
128	8	Not used

For example an E-mask value 252 (4 + 8 + 16 + 32 + 64 + 128) will specify that error numbers 3 thru 8 can set the error bit in the status byte and turn on the error light whenever they occur. Errors 1 and 2, however, will not set the error bit or turn on the error light if they occur since they are not included in the E-mask value.

The S-mask value specifies the status-byte conditions that can send the require service message by setting interface line SRQ to a logical 1.

The S-mask is the decimal equivalent of the bit values of the selected status-byte bits.

S-Mask Bit Values	Status Bit	Meaning
1	0	Pen down
2	1	P1 or P2 changed from default; cleared on "OP"
4	2	Digitized point available; cleared on "OD"
8	3	Initialized; cleared on "OS"
16	4	Ready for data
32	5	Error; cleared on "OS"
	6	Require service sent (SRQ)
	7	Not used

Only combinations of the first 6 bits can be specified to send the require service message. Bit 6 is used to specify whether or not the plotter has sent the require service message or not and bit 7 is not used (always set to logical 0).

For example, an S-mask value of 16 specifies that the ready for data bit (bit 4) of the status byte will send the require service message. The other 5 bits (bits 0 thru 3 and bit 5) will not send the require service message.

The P-mask value specifies which of the status-byte conditions that will result in a logical 1 response to a parallel poll.

P-Mask Bit Value	Status Bit Number	Meaning
1	0	Pen down
2	1	P1 or P2 changed
4	2	Digitized point available
8	3	Initialized
16	4	Ready for data
32	5	Error
	6	Require service sent (SRQ)
	7	Not used

For example, a P-mask value of 48 specifies that only bits 4 and 5 (16 + 32) of the status byte can cause the plotter to respond to a parallel poll with a logical 1 on the appropriate data line.

The plotter, when cleared or initialized, automatically sets the E-mask to 223 (error numbers 1, 2, 3, 4, 5, 7, 8), the S-mask to 0 (none of the status-byte bits can send the require service message) and the P-mask to 0 (none of the status-byte bits can cause a parallel poll response of logical 1).

An IM command with no parameters (IM;) will automatically set the values to 223, 0, 0.

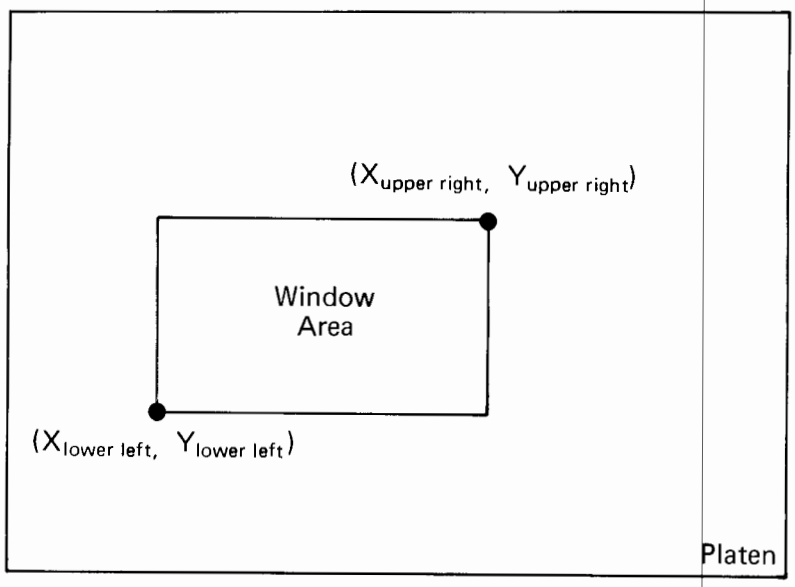
The Input Window Instruction IW

The input window instruction IW provides the means to restrict the programmed pen motion to a specific rectangular area on the platen. This area is called the "window".

Syntax:

IW X lower left, Y lower left, X upper right, Y upper right [; or LF]

The four parameters specify, in absolute plotter units, the X and Y coordinates of the lower left and the upper right corners of the window area as shown below.



If command IW is not executed, or if executed without parameters (IW;) the window is automatically set at the mechanical limits of the plotter.

There are in general four types of vectors that can be developed from a given "last point" to some "new point" as follows:

	Last Point		New Point
1.	Inside window area	to	inside window area
2.	Inside window area	to	outside window area
3.	Outside window area	to	inside window area
4.	Outside window area	to	outside window area

In type 1, the pen will move as programmed from the last point to the new point with the pen up or down as commanded.

In type 2, the pen will move as programmed from the last point toward the new point. At the intersection of this move and the window limit, the pen will stop and lift, and the OUT OF LIMITS light will come on.

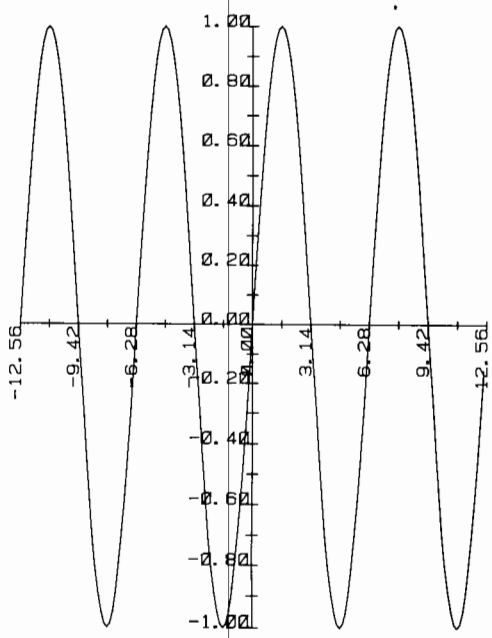
In type 3, the OUT OF LIMITS light is on at the start of the vector. The pen will move (pen up) to the intersection of the current vector and the window limit. At this point, the OUT OF LIMITS light will go out, the pen will be under control either pen up or down as instructed, and will move to the new point.

In type 4, the pen is raised and the OUT OF LIMITS light is on at the start of the vector. If part of the vector is in the window area, the plotter will move with the pen up to the intersection of the current vector and the window limit nearest the last point. The light will go out and the pen will be moved under program control to the intersection of the vector and the other window limit. The pen will then stop and lift and the OUT OF LIMITS light will come on. If the vector from the last point to the new point does not intersect the window area, no move will be made.

If either set of coordinates is larger than ±32767 plotter units, no pen move will be made and the plotter will assume an over-range condition. While in over-range, commands CP, LB, PR, UC, XT, and YT are ignored until receipt of a PA command moving the pen within the ±32767 plotter unit limitation. While in over-range, the OUT OF LIMITS light will flash. If the PA command moves the pen within the limitation but outside the window area from an over-range condition, no pen movement will occur, the OUT OF LIMITS light will be on without flashing, and the over-range mode will be exited.

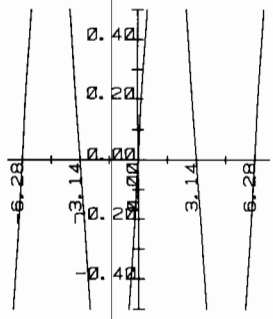
The input window command can be used to specify a limited portion of the plot. The following example using the 9830A plots the function sin X from -4π to 4π and -1 to 1. The same program is then run, but with the window command inserted to demonstrate the "windowing" effect.

```
10 FORMAT 2F6.0
20 FORMAT F6.2,B
30 CMD "?U%"
40 OUTPUT (13,*)"SP1;PA520,5000;PD;XT"
50 FOR I=1 TO 16
60 OUTPUT (13,10)"PR400,0;XT"
70 NEXT I
80 OUTPUT (13,*)"PU;PA520,5000;DI0,1;CP-6,0"
90 FOR J=-12.56 TO 12.56 STEP 3.14
100 OUTPUT (13,20)"LB",J,3,"CP-6,0;PU;PR800,0"
110 NEXT J
120 OUTPUT (13,*)"PA3720,1000;PD;YT"
130 FOR K=1 TO 20
140 OUTPUT (13,*)"PR0,400;YT"
150 NEXT K
160 OUTPUT (13,*)"PU;PA3720,1000;DI;CP-6,0"
170 FOR L=-1 TO 1 STEP 0.2
180 OUTPUT (13,20)"LB",L,3,"CP-6,0;PU;PR0,800"
190 NEXT L
200 FOR X=-4*PI TO 4*PI STEP PI/20
210 Y=SINX
220 A=(6400/25.14)*X+3720
230 B=4000*SINX+5000
240 OUTPUT (13,10)"PA",A,",",B,"PD"
250 NEXT X
260 OUTPUT (13,*)"PU;SP0;PA16000,11400"
270 END
```




```
10 FORMAT 2F6.0
20 FORMAT F6.2,B
30 CMD "?U%"
35 OUTPUT (13,*)"IW 1920,3000,5520,7000"
40 OUTPUT (13,*)"SP1;PA520,5000;PD;XT"
50 FOR I=1 TO 16
60 OUTPUT (13,10)"PR400,0;XT"
70 NEXT I
80 OUTPUT (13,*)"PU;PA520,5000;DI0,1;CP-6,0"
90 FOR J=-12.56 TO 12.56 STEP 3.14
100 OUTPUT (13,20)"LB",J,3,"CP-6,0;PU;PR800,0"
110 NEXT J
120 OUTPUT (13,*)"PA3720,1000;PD;YT"
130 FOR K=1 TO 20
140 OUTPUT (13,*)"PR0,400;YT"
150 NEXT K
160 OUTPUT (13,*)"PU;PA3720,1000;DI;CP-6,0"
170 FOR L=-1 TO 1 STEP 0.2
180 OUTPUT (13,20)"LB",L,3,"CP-6,0;PU;PR0,800"
190 NEXT L
200 FOR X=-4*PI TO 4*PI STEP PI/20
210 Y=SINX
220 A=(6400/25.14)*X+3720
230 B=4000*SINX+5000
240 OUTPUT (13,10)"PA",A,",",B,"PD"
250 NEXT X
260 OUTPUT (13,*)"PU;SP0;PA16000,11400"
270 END
```

Input window command sets the window for the sin X plot.



The Default Instruction DF

The default instruction DF provides the means to set certain plotter functions to a predefined state.

Syntax:

DF [; or LF]

No parameters are used, however the terminator ; or LF must be included to complete the command.

A DF command sets the following plotter functions to the conditions shown:

Default Conditions

Function	Conditions
Relative character direction	Horizontal (DR1,0)
Line type	Solid line
Line pattern length	4% of the distance from P1 to P2
Input window	Total platen area
Relative character size	0.75 x 1.5 cm
Automatic pen pickup	on
Pen velocity	36 cm/s
Adaptive pen velocity	off
Symbol mode	off
Tick length	.5% of |P2 - P1|
Standard character set	Set 0
Alternate character set	Set 0
Character slant	0°
Mask value	223,0,0
Digitize clear	on

P1 and P2 are not changed

The current pen location is not changed.

The Initialize Instruction IN

The initialize instruction IN provides the means of returning the plotter to the initial power-on state by program control.

Syntax:

IN [; or LF]

No parameters are used, however the terminator ; or LF must be included to complete the command.

An IN command is the equivalent of switching the plotter off and then on again or initializing it from the front panel. The initialize command sets the plotter to the same conditions as the default command and sets these additional conditions.

The pen is moved to the lower right corner of the platen.

The scaling points P1 and P2 are set to the points P1 = (520, 380) and P2 = (15720, 10380).

All errors are cleared and bit position 3 of the output status word is set true (1).

The Output Error Instruction OE

The output error instruction OE provides the means to make the decimal equivalent of the current error (if any) available for output.

Syntax:

OE [; or LF]

No parameters are used, however the terminator ; or LF must be included to complete the command.

When the plotter is instructed to talk and the controller instructed to listen after an OE command, the plotter will output a positive ASCII integer in the form:

error number CR LF

The error numbers are defined as follows:

Error Number	Meaning
0	No error
1	Instruction not recognized
2	Wrong number of parameters
3	Out of range parameters
4	Illegal characters
5	Unknown character set
6	Position overflow
7	Not used (always 0)
8	Not used (always 0)

After outputting the error code to the controller, bit position 5 of the output status byte is cleared, and the ERROR light (if lit) is turned off.

The Output Status Instruction OS

The output status instruction OS provides the means to make the decimal equivalent of the output status byte available for output.

Syntax:

OS [; or LF]

No parameters are used, however the terminator ; or LF must be included to complete the command.

Upon receipt of the OS command, the internal eight-bit status byte is converted to an ASCII decimal integer between 0 and 255. When the plotter is instructed to talk and the controller instructed to listen, the plotter will output a decimal integer in the form:

status CR LF

The status byte bits are defined as follows:

Bit Value	Bit Position	Meaning
1	0	Pen down
2	1	P1 or P2 changed
4	2	Digitized point available
8	3	Initialized
16	4	Ready for data
32	5	Error
64	6	Require service message set
128	7	Not used (always set to 0)

Upon power up, the status is digital 24, the sum of 8 (initialized) and 16 (ready for data). Upon completion of the OS command, bit position 3 is cleared.

External Plotter Commands

How To Use Clear Commands DCL and SDC

The controller can set all devices on the HP-IB system to a predefined or initialized state by sending device clear command DCL. The controller can also set selected devices to a predefined or initialized state by sending selected device clear command SDC along with the addresses of the devices. The basic difference is that devices will obey SDC only if they are addressed to listen, whereas DCL clears all devices on the bus.

Upon receipt of either DCL or SDC commands, the 9872A plotter will complete the present vector being drawn, then stop and lift the pen.

The device clear commands set all parameters that have been sent to the plotter to their default values with the following exceptions:

The current plotter address codes remain unchanged.

P1 and P2 remain unchanged.

The current pen location remains unchanged although the pen is raised.

The pen that is selected remains unchanged.

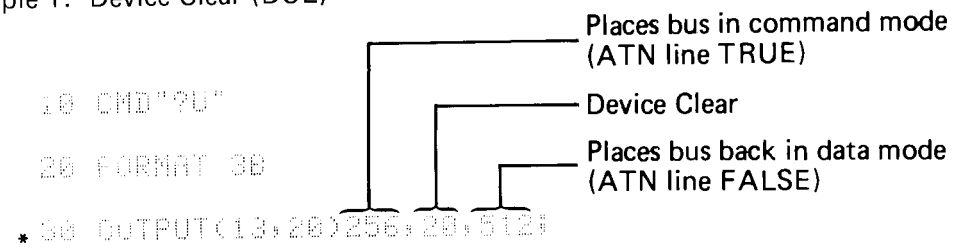
A complete listing of the default values for each statement's parameters is listed under the default instruction DF.

NOTE

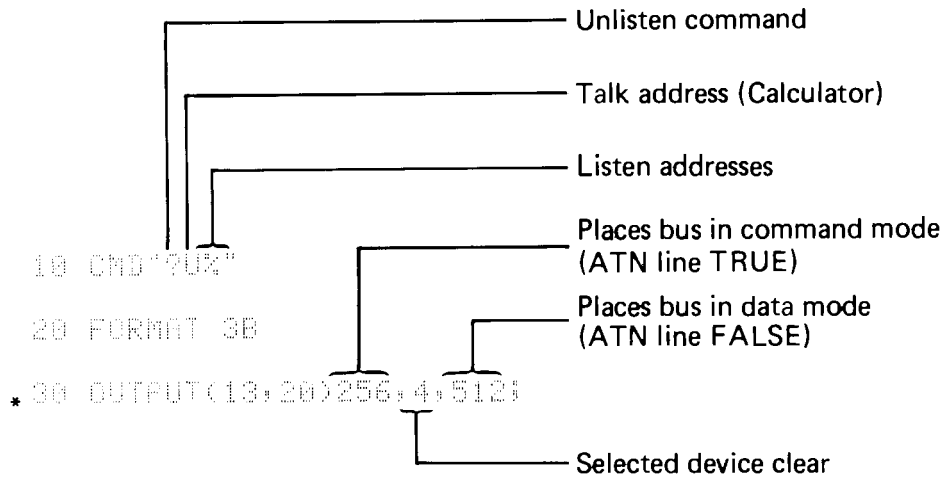
It is a good practice to execute a clear command or initialize at the beginning of each program to clear any previously set conditions in the plotter.

The following examples use the 9830A calculator to provide clear commands:

Example 1: Device Clear (DCL)



Example 2: Selected Device Clear (SDC)



*NOTE: Commands SDC and DCL must be sent with the bus set to the "command" mode (i.e., ATN line TRUE). The 9830A does this by using binary 256 in its output statement as shown by line 30. Binary 512 returns the bus to the data mode. This convention is unique to the 9830A. Other controllers use different methods of controlling the ATN line.

Serial And Parallel Polling

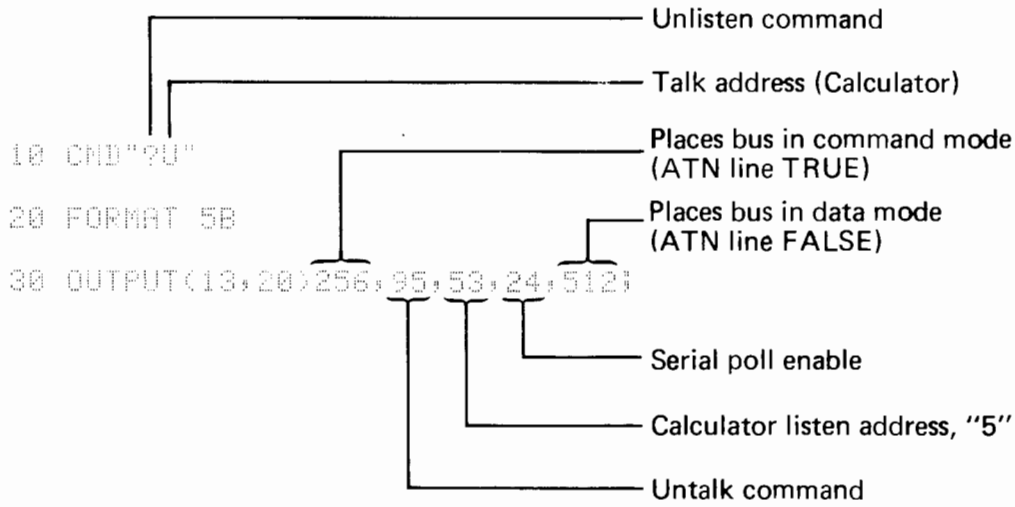
The Serial Poll

A serial poll enables the controller to learn the status or condition of devices on the bus. The serial poll is so named because the controller polls devices one at a time in sequence rather than all at once. When polled, a device transmits a single byte of information to indicate the status of the device. In order to respond, the plotter must be instructed to talk and the controller to listen.

Starting a Serial Poll

The Serial Poll Enable bus command starts a serial poll. During a serial poll the controller must be addressed to listen so that it can receive the status byte from each device that it polls.

A typical 9830A Calculator program might initiate a serial poll as follows:

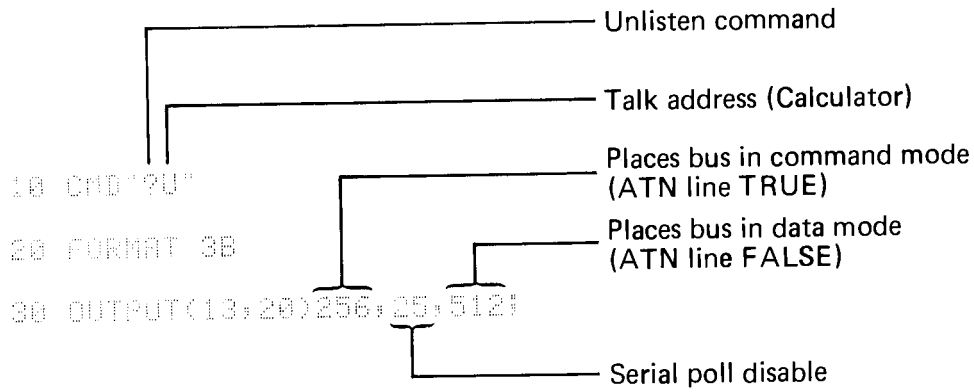


The CMD statement addresses the calculator to talk so that the calculator can execute the OUTPUT statement. The OUTPUT statement issues the untalk command, addresses the calculator to listen, then sets the serial poll mode.

*NOTE: The plotter will then respond by sending to the controller the same status byte that would be sent if the OS instruction was requested (see Output Status Instruction, Chapter 6). If the seventh bit of this status byte is a "zero", the plotter has not requested service. If the seventh byte is a "one", the plotter has requested service.

Ending a Serial Poll

At the end of a serial poll the controller resumes normal bus operations by issuing the serial poll disable bus command. SPD does not change the addressed talker and listeners. To end a serial poll, the 9830A uses the statements:



The Parallel Poll

The plotter can also respond to a parallel poll by sending a logical 1 on one of the 8 data lines. The line used is determined by the plotter's address value as shown in the table below:

Plotter Address	Parallel Poll Bit Position	HP-IB Data Line Number	
0	7	8	
1	6	7	
2	5	6	
3	4	5	
4	3	4	
5	2	3	← 9872A Preset Address
6	1	2	
7	0	1	

The address settings from 8 thru 30 will not respond to a parallel poll.

To execute a parallel poll, the controller sends the universal parallel poll enable command, reads the eight data lines, and determines from these lines which instrument on the bus is requesting service. The controller then sends the universal parallel poll disable command. Not all controllers have parallel poll capability.

Chapter 7
Scaling

This chapter describes the instructions that enable you to scale the plot into user units.

The Input P1 and P2 Instruction IP

The input P1 and P2 instruction IP provides the means to relocate the scaling points P1 and P2 through program control.

Syntax:

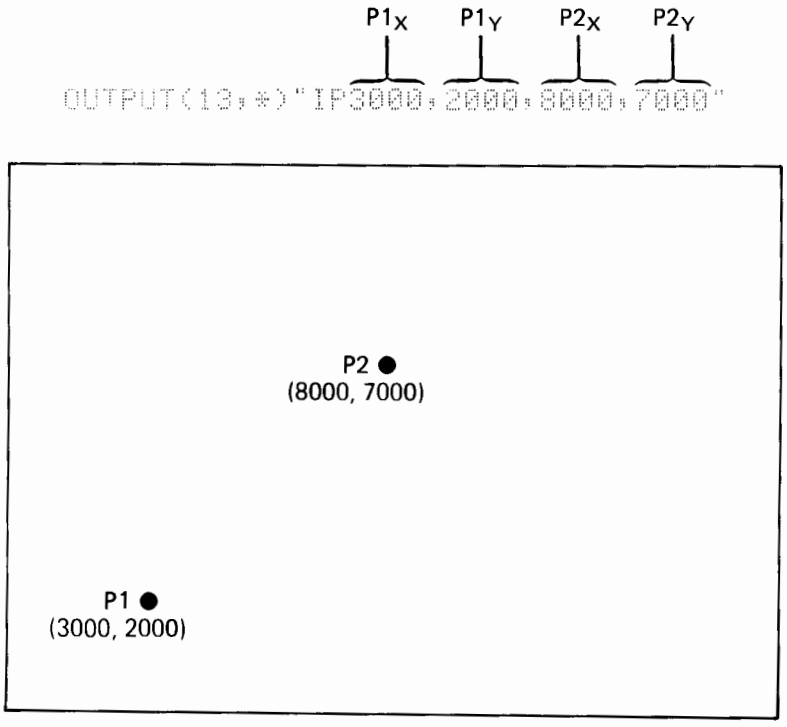
IP $P1_X$, $P1_Y$, $P2_X$, $P2_Y$ [; or LF]

The new coordinates of P1 and P2 are specified in the order shown above and must be in absolute plotter units.

Upon receipt of a valid IP command, bit position 1 of the output status word is set true (1). A command IP with no parameters (IP;) will default to the values P1=520, 380 and P2=15720, 10380.

Upon initialization, character size is set relative (SR) to the locations of P1 and P2. Unless an SI command has been entered as part of the program, the character size will be directly affected by the IP command.

The following example using the 9830A relocates the scaling points P1 and P2 to the positions shown on the figure.



It may be desired to relocate the scaling points using front panel controls rather than a program instruction. An explanation of this method is included under Setting the Scaling Points, Chapter 1.

The Output P1 and P2 Instruction OP

The output P1 and P2 instruction OP provides the means to make the current coordinates of the scaling points P1 and P2 (in absolute plotter units) available for output.

Syntax:


```
OP [; or LF]
```

No parameters are used, however the terminator ; or LF must be included to complete the command.

When the plotter is instructed to talk and the controller instructed to listen after an OP command, the plotter will output the coordinates in the following form:

$P1_X$, $P1_Y$, $P2_X$, $P2_Y$ CR LF

Upon completion of output, bit position 1 of the output status word is cleared.

The following partial listing from a program using the 9830A demonstrates the use of the OP command:

```
40 OUTPUT(13,*)"SP1;OP"
50 CMD"?E5"
60 ENTER(13,*)A,B,C,D
70 CMD"?U%"
```

Line 40 commands the plotter to output the new scaling points which may have been entered by front panel controls.

Line 50 commands the plotter to talk and the controller to listen.

Line 60 enters the new scaling points into the variables A, B, C, and D for further use in the program.

Line 70 returns the controller to talker and the plotter to listener.

Scaling

The 9872A plotter movements are in terms of plotter units where 1 plotter unit = 0.025 mm. It may be convenient for you to write programs where plotter movements are in some units other than plotter units. These "user units" can be converted into plotter units by the controller using the following equations:

$$X\ scaled = \left[\frac{P2_X - P1_X}{U2_X - U1_X}\right] A_X + P1_X - U1_X \left[\frac{P2_X - P1_X}{U2_X - U1_X}\right]$$

$$Y\ scaled = \left[\frac{P2_Y - P1_Y}{U2_Y - U1_Y}\right] A_Y + P1_Y - U1_Y \left[\frac{P2_Y - P1_Y}{U2_Y - U1_Y}\right]$$

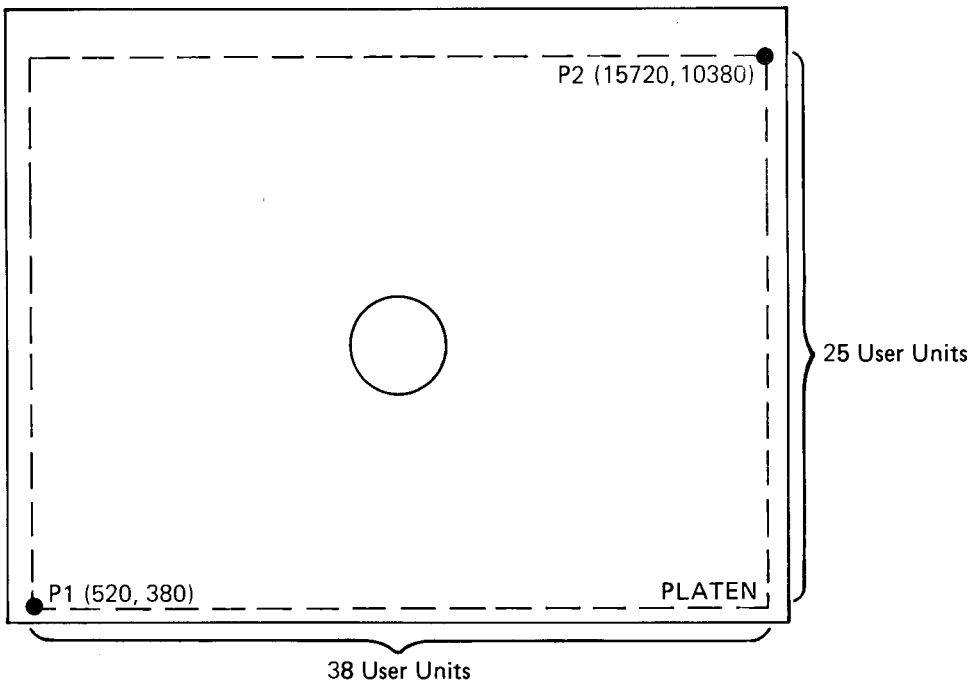
where: A_X is the X coordinate of the desired point in user units
A_Y is the Y coordinate of the desired point in user units
$P1_X$ is the X coordinate of P1 in plotter units
$P1_Y$ is the Y coordinate of P1 in plotter units
$P2_X$ is the X coordinate of P2 in plotter units
$P2_Y$ is the Y coordinate of P2 in plotter units
$U1_X$ is the X coordinate of P1 in user units
$U1_Y$ is the Y coordinate of P1 in user units
$U2_X$ is the X coordinate of P2 in user units
$U2_Y$ is the Y coordinate of P2 in user units

To demonstrate the use of the scaling equations, let's go through a few examples.

Example 1:

Problem

Scale the platen default area (P1=520, 380 and P2=15720, 10380) into user units where P1=0,0 and P2=38, 25 cm. At the center point (X=19, Y=12.5 cm), draw a 2.5 cm radius circle as follows:



Solution

A. Recall that the equations of a circle are

$$X = R \cos t$$
$$Y = R \sin t$$
where $0 \leqslant t \leqslant 2\pi$

B. Since we are to plot relative to a point that is not at the origin, an offset X_O, Y_O must be added to the circle equations. The offset in user units is

$$X_O = 19$$
$$Y_O = 12.5$$

C. The desired circle equations are then:

$$A_X = 2.5 \cos t + 19$$
$$A_Y = 2.5 \sin t + 12.5$$

D. Determine the user scale:

$$X = 0 \text{ to } 38$$
$$Y = 0 \text{ to } 25$$

therefore

$$U1_X = 0$$
$$U1_Y = 0$$
$$U2_X = 38$$
$$U2_Y = 25$$

E. Determine the values for P1 and P2 which were set using DF or IN commands:

$P1 = 520, 380$

$P2 = 15720, 10380$

therefore

$P1_X = 520$

$P1_Y = 380$

$P2_X = 15720$

$P2_Y = 10380$

F. Solving for X and Y:

$$X = \left[\frac{P2_X - P1_X}{U2_X - U1_X}\right] A_X + P1_X - U1_X \left[\frac{P2_X - P1_X}{U2_X - U1_X}\right]$$

$$= \left[\frac{15720 - 520}{38 - 0}\right] [2.5 \cos t + 19] + 520 - 0 \left[\frac{15720 - 520}{U2_X - U1_X}\right]$$

$$= 400 (2.5 \cos t + 19) + 520 - 0$$

$$= 1000 \cos t + 8120$$

$$Y = \left[\frac{P2_Y - P1_Y}{U2_Y - U1_Y}\right] A_Y + P1_Y - U1_Y \left[\frac{P2_Y - P1_Y}{U2_Y - U1_Y}\right]$$

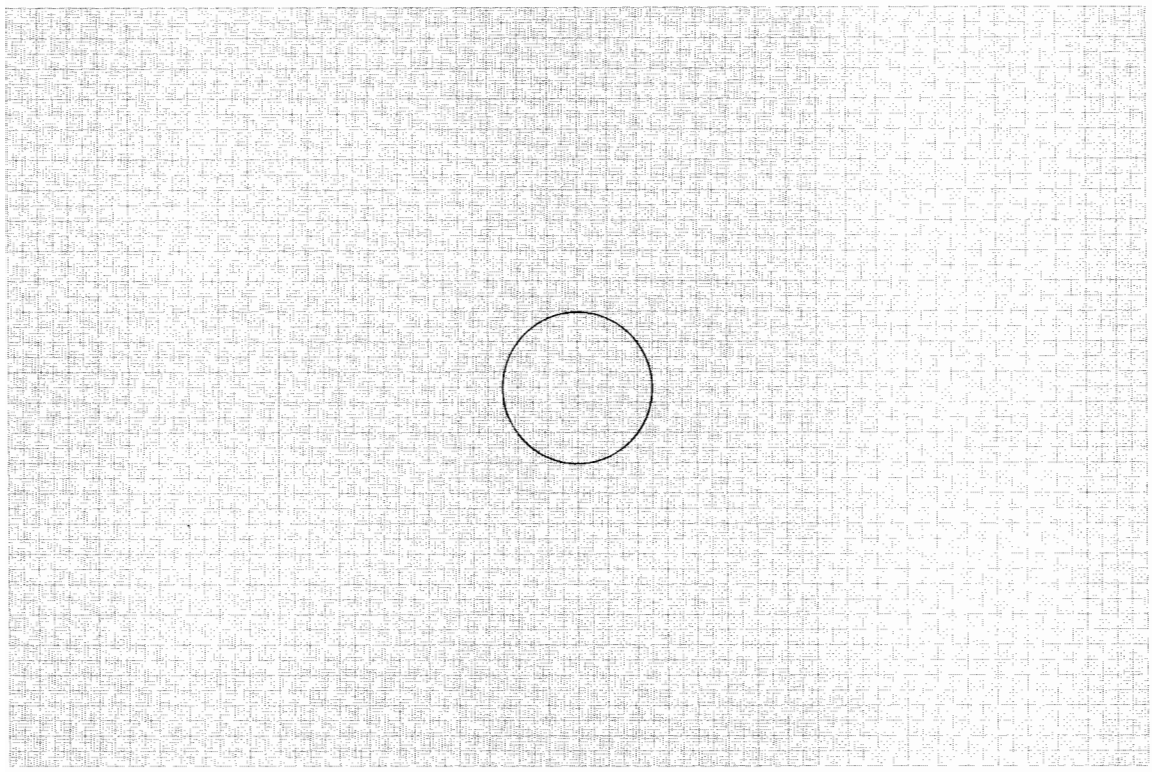
$$= \left[\frac{10380 - 380}{25 - 0}\right] [2.5 \sin t + 12.5] + 380 - 0 \left[\frac{10380 - 380}{25 - 0}\right]$$

$$= 400 (2.5 \sin t + 12.5) + 380 - 0$$

$$= 1000 \sin t + 5380$$

G. Putting this all together, the following program using the 9830A will plot the required circle:

```
505 FORMAT 2F6.0
510 CMD "?U%"
520 OUTPUT (13,*)"SP1"
530 FOR T=0*PI TO 2*PI STEP PI/20
540 X=1000*COST+8120
550 Y=1000*SINT+5380
560 OUTPUT (13,505)"PA",X,",",Y,"PD"
570 NEXT T
580 OUTPUT (13,*)"PU;SP0"
590 END
```



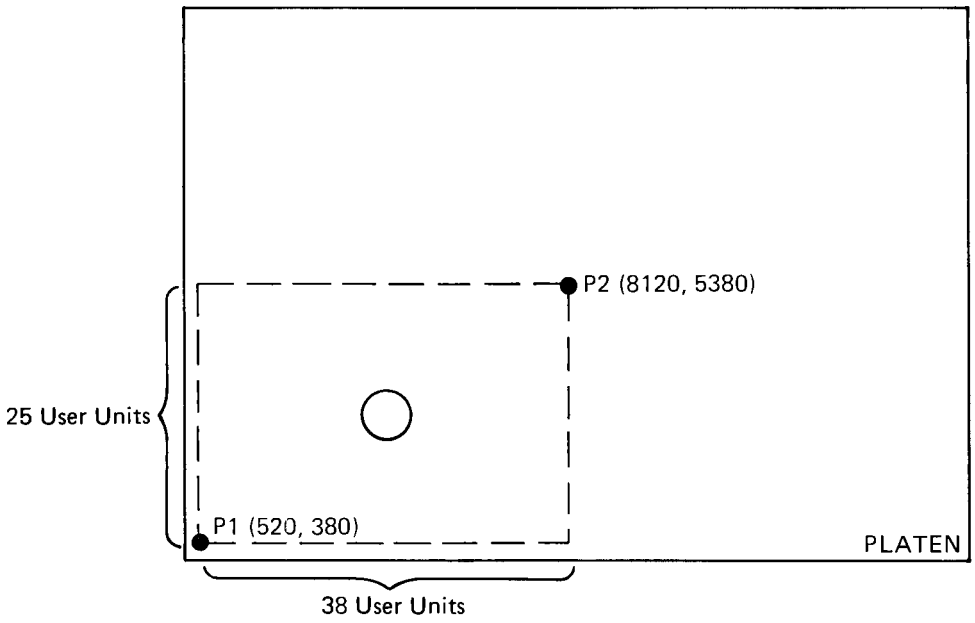
This program could be modified to use a subroutine to do the job of scaling. In this case, the equations in lines 540 and 550 would be programmed in user units and line 560 is replaced by a "GOSUB" statement. The subroutine at Line 9000 scales and plots the circle.

```
510 CMD "?U%"
520 OUTPUT (13,*)"SP1"
530 FOR T=0*PI TO 2*PI STEP PI/20
540 X=2.5*COST+13
550 Y=2.5*SINT+12.5
560 GOSUB 9000
570 NEXT T
580 OUTPUT (13,*)"PU;SP0"
590 END
9000 CMD "?U%","OP;"
9010 CMD "?E5"
9020 ENTER (13,9030)X1,Y1,X2,Y2
9025 CMD "?U%"
9030 FORMAT 4F6.0
9040 A=((X2-X1)/(30-0))*X+X1
9050 B=((Y2-Y1)/(25-0))*Y+Y1
9060 OUTPUT (13,9070)"PA",A,",",B,"PD"
9070 FORMAT 2F6.0
9080 RETURN
```

Lines 9000 thru 9030 send the values of $P1_X$, $P1_Y$, $P2_X$, $P2_Y$ to the calculator and assign them to the variables X1, Y1, X2, Y2 respectively. Lines 9040 and 9050 are the scaling equations.

Example 2:

Now let's take the problem of example 1 and scale it into the lower quadrant of the platen default area. Let P1 = 520, 380 and P2 = 8120, 5380 and draw the circle in the same relationship as shown below:



Solution:

A-D. Steps A, B, C, and D are the same as example 1.

E. Determine the values for P1 and P2:

P1 = 520, 380

P2 = 8120, 5380

therefore

$P1_X = 520$

$P1_Y = 380$

$P2_X = 8120$

$P2_Y = 5380$

F. Solving for X and Y:

$$X = \left[\frac{P2_X - P1_X}{U2_X - U1_X}\right] A_X + P1_X - U1_X \left[\frac{P2_X - P1_X}{U2_X - U1_X}\right]$$

$$= \left[\frac{8120 - 520}{38 - 0}\right][2.5 \cos t + 19] + 520 - 0 \left[\frac{8120 - 520}{38 - 0}\right]$$

$$= 200 (2.5 \cos t + 19) + 520 - 0$$

$$= 500 \cos t + 4320$$

$$Y = \left[\frac{P2_Y - P1_Y}{U2_Y - U1_Y}\right] A_Y + P1_Y - U1_Y \left[\frac{P2_Y - P1_Y}{U2_Y - U1_Y}\right]$$

$$= \left[\frac{5380 - 380}{25 - 0}\right][2.5 \sin t + 12.5] + 380 - 0 \left[\frac{5380 - 380}{25 - 0}\right]$$

$$= 200 (2.5 \sin t + 12.5) + 380 - 0$$

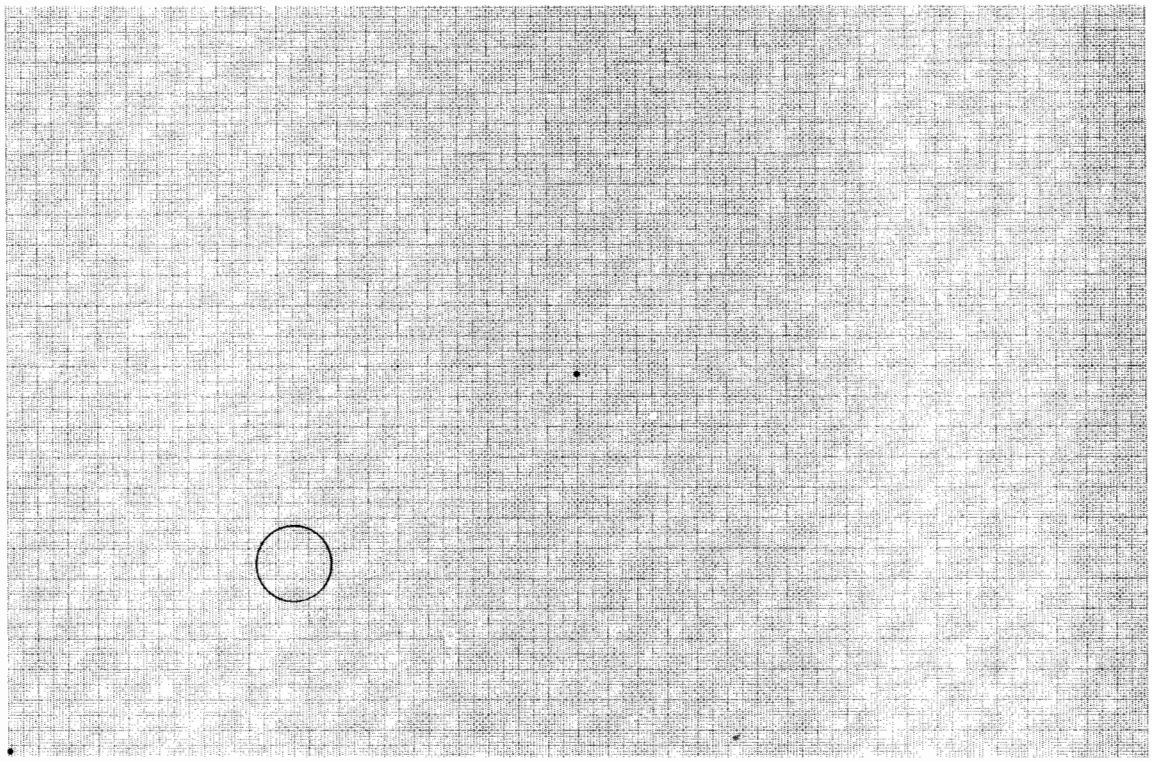
$$= 500 \sin t + 2880$$

G. The following program using the 9830A will plot the required circle:

```
10 CMD "?U%"
15 FORMAT 2F6.0
20 A=B=C=D=X=Y=0
30 OUTPUT (13,*)"IP520,380,8120,5380"
40 FOR T=0*PI TO 2*PI STEP PI/20
50 X=500*COST+4320
60 Y=500*SINT+2880
70 OUTPUT (13,15)"SP1;PA",X,",",Y,"PD"
80 NEXT T
90 OUTPUT (13,*)"PU;SP0"
100 END
```

This portion of the program inputs the new P1 and P2 points to the plotter.

The X and Y scaled values including offset are entered here.



Example 3:

Problem:

In user units do the following within the platen default area of P1 = 520, 380 and P2 = 15720, 10380:

1. Draw, tick mark, and label the X axis centered on the page. Labeling and tick marks to be -10 to 10 in 1 unit increments.

2. Draw, tick mark, and label the Y axis centered on the page. Labeling and tick marks to be -100 to 100 in 10 unit increments.

3. Change the pen and draw the curve $Y = X^2$ over the range $-10 \leqslant X \leqslant 10$.

4. Change the pen and draw the line $Y = -10X$ over the range $-10 \leqslant X \leqslant 10$.

5. Change the pen and draw the line $Y = 10X$ over the range $-10 \leqslant X \leqslant 10$. Store the pen.

Solution:

A. To plot the X axis, first we have to determine the scaling. We know P1 = 520, 380, P2 = 15720, 10380, U1 = -10, -100, and U2 = 10, 100.

Therefore

$P1_X = 520$ $\quad U1_X = -10$

$P1_Y = 380$ $\quad U1_Y = -100$

$P2_X = 15720$ $\quad U2_X = 10$

$P2_Y = 10380$ $\quad U2_Y = 100$

and

$$X\ \text{scaled} = \left[\frac{P2_X - P1_X}{U2_X - U1_X}\right] A_X + P1_X - U1_X \left[\frac{P2_X - P1_X}{U2_X - U1_X}\right]$$

$$= \left[\frac{15720 - 520}{10 - (-10)}\right] A_X + 520 - (-10) \left[\frac{15720 - 520}{10 - (-10)}\right]$$

$$= 760\, A_X + 8120$$

$$Y\ \text{scaled} = \left[\frac{P2_Y - P1_Y}{U2_Y - U1_Y}\right] A_Y + P1_Y - U1_Y \left[\frac{P2_Y - P1_Y}{U2_Y - U1_Y}\right]$$

$$= \left[\frac{10380 - 380}{100 - (-100)}\right] A_Y + 380 - (-100) \left[\frac{10380 - 380}{100 - (-100)}\right]$$

$$= 50\, A_Y + 5380$$

since A_Y will have a scaled value of 0, Y scaled for the X axis becomes:

$$\begin{aligned} Y \text{ scaled} &= 50(0) + 5380 \\ &= 5380 \end{aligned}$$

B. The same scaling equations hold for the Y axis, but since A_X will have a scaled value of 0, X scaled for the Y axis becomes:

$$\begin{aligned} X \text{ scaled} &= 760(0) + 8120 \\ &= 8120 \end{aligned}$$

and

$$Y \text{ scaled} = 50\ A_Y + 5380$$

C. A simple loop can be set up as in lines 60 through 90 of the sample program to plot, incrementing over the required range.

D. Labeling as in steps 170 through 210 use a simple loop with the original scaling equations.

E. For the functions $Y = X^2$, $Y = -10X$, $Y = 10X$, merely substitute the incrementing variable for A_X and the Y function of the incrementing variable for A_Y in the scaling equations as follows:

For $Y = X^2$, using M as the variable

$$X \text{ scaled} = 760M + 8120$$
$$Y \text{ scaled} = 50(M^2) + 5380$$

For $Y = 10X$, using N as the variable

$$X \text{ scaled} = 760N + 8120$$
$$Y \text{ scaled} = 50(-10N) + 8120$$

The following program using the 9830A draws the axes and plots the three functions using four different pens:

```
10 FORMAT 2F6.0
20 FORMAT F4.0,B
30 FORMAT B
40 CMD "?U%"
50 OUTPUT (13,*)"SP1"
60 FOR I=-10 TO 10
70 X=760*I+8120
75 Y=5380
80 OUTPUT (13,10)"PA",X,",",Y,"PD;XT"
90 NEXT I
100 OUTPUT (13,*)"PU"
110 FOR J=-100 TO 100 STEP 10
120 X=8120
130 Y=50*J+5380
140 OUTPUT (13,10)"PA",X,",",Y,"PD;YT"
150 NEXT J
160 OUTPUT (13,*)"PU"
170 FOR K=-10 TO 10
180 X=760*K+8120
190 Y=5380
200 OUTPUT (13,10)"PA",X,",",Y,"DI0,1;CP-4,-.25"
205 OUTPUT (13,20)"LB",K,3
210 NEXT K
220 FOR L=-100 TO 100 STEP 10
230 X=8120
240 Y=50*L+5380
250 OUTPUT (13,10)"PA",X,",",Y,"DI;CP-4,-.25'
260 OUTPUT (13,20)"LB",L,3,"PU"
270 NEXT L
275 OUTPUT (13,*)"SP2"
280 FOR M=-10 TO 10 STEP 0.1
290 X=760*M+8120
300 Y=50*M↑2+5380
310 OUTPUT (13,10)"PA",X,",",Y,"PD"
320 NEXT M
330 OUTPUT (13,*)"PU;SP3"
340 FOR N=-10 TO 10 STEP 0.1
350 X=760*N+8120
360 Y=-500*N+5380
370 OUTPUT (13,10)"PA",X,",",Y,"PD"
380 NEXT N
390 OUTPUT (13,*)"PU;SP4"
400 FOR P=-10 TO 10 STEP 0.1
410 X=760*P+8120
420 Y=500*P+5380
430 OUTPUT (13,10)"PA",X,",",Y,"PD"
440 NEXT P
450 OUTPUT (13,*)"PU;SP0"
460 END
```

This portion draws the X axis complete with tick marks.

This portion draws the Y axis complete with tick marks.

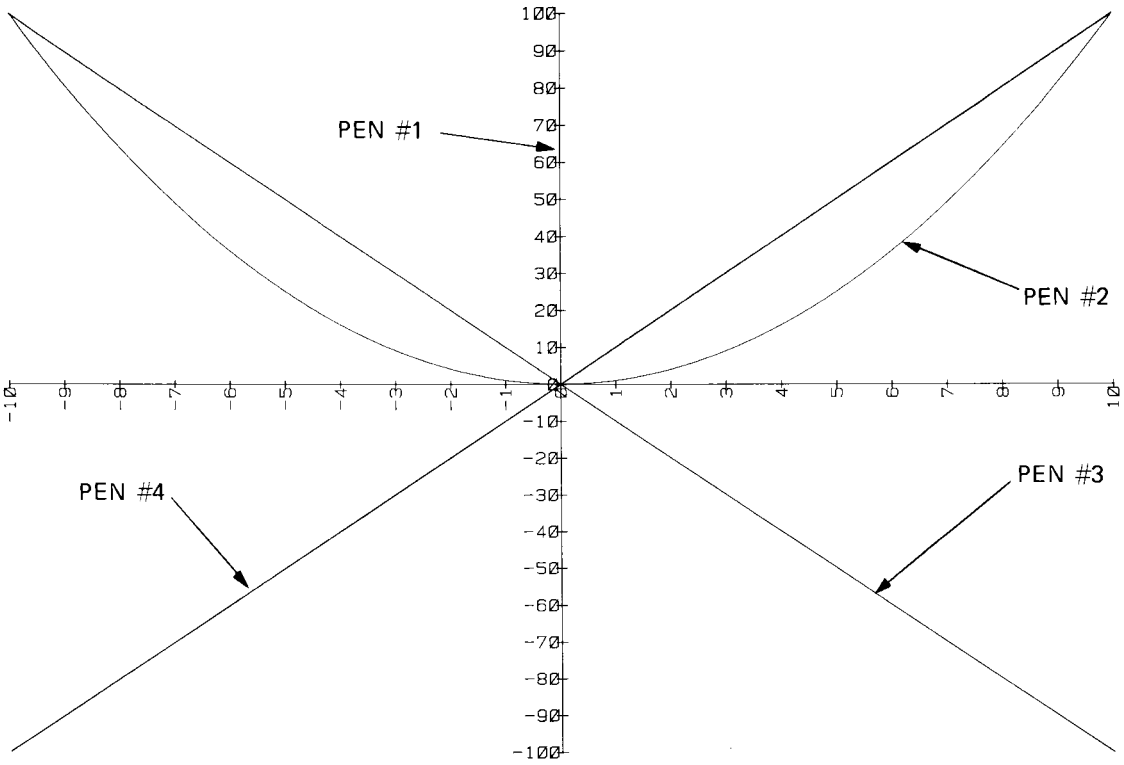
This portion labels the X axis.

This portion labels the Y axis.

This portion draws the curve $Y = X^2$

This portion draws the line Y = -10X.

This portion draws the line Y = 10X and stores the pen.



Example 3 Plot

Appendix

Binary Coding and Conversions

Binary is a base 2 number system using only 1's and 0's. By giving the 1's and 0's positional value, any decimal number can be represented. For example, this diagram shows how decimal 41 = binary 101001:

Decimal		Binary					
10^1	10^0	2^5	2^4	2^3	2^2	2^1	2^0
↓	↓	↓	↓	↓	↓	↓	↓
10	1	32	16	8	4	2	1
4	1	1	0	1	0	0	1

Binary-Decimal Conversions

To convert from binary to decimal, the positional values of the 1's are added up. From the above example this would be:

$$2^5 + 2^3 + 2^0 = 32 + 8 + 1 = 41$$

To convert from decimal to binary, the decimal number is repeatedly divided by 2. The remainder is the binary equivalent. For example:

		Remainder (read up)
$2\overline{)41}$	→	1
$2\overline{)20}$	→	0
$2\overline{)10}$	→	0
$2\overline{)5}$	→	1
$2\overline{)2}$	→	0
$2\overline{)1}$	→	1

Octal-Binary Conversions

Octal is a base 8 number system. Octal numbers are often used since conversion from binary to octal and vice-versa is easy when electronic circuits are used.

To convert from binary to octal, the octal number is broken up into groups of three bits (starting from the right). Each 3 bit group represents an octal number.

For example, to convert binary 10110100011001 to octal:

Binary Number	10	110	100	011	001
	↓	↓	↓	↓	↓
Octal Number	2	6	4	3	1

Notice that only values from 0 through 7 are used in octal.

To convert from octal to binary, the process is reversed:

Octal Number	1	4	0	7	2	6
	↓	↓	↓	↓	↓	↓
Binary Number	001	100	000	111	010	110

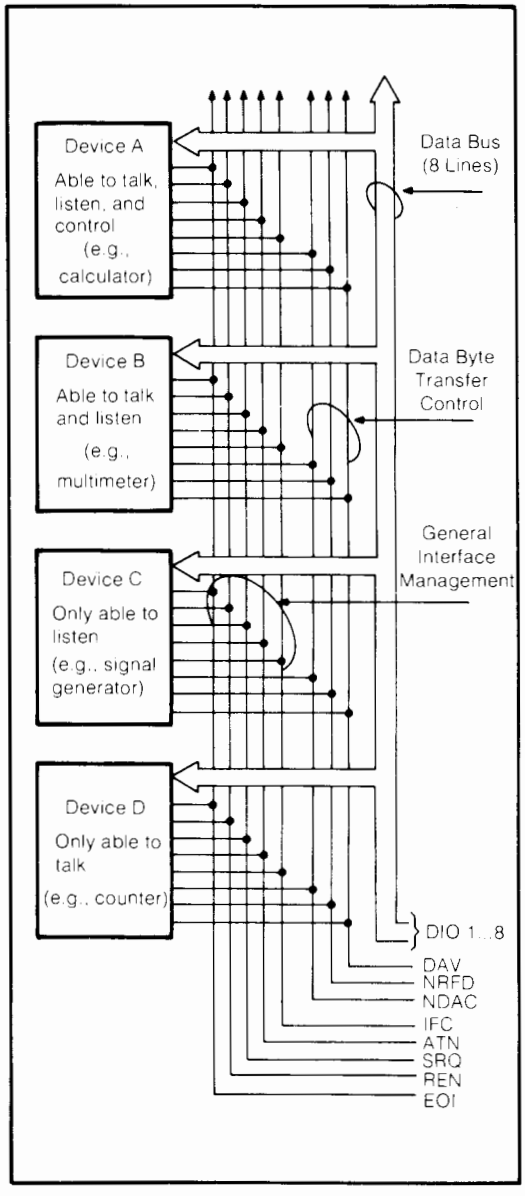
The HP Interface Bus

This section provides a brief overview of the HP-IB hardware and control scheme. Sufficient information is provided to obtain an understanding of operation via HP-IB. For a more detailed explanation of HP-IB from a controller's standpoint, refer to the system controller operating manual.

HP-IB Lines and Operations

The HP Interface Bus transfers data and commands between the components of an instrumentation system on 16 signal lines. The interface functions for each system component are performed within the component so only passive cabling is needed to connect the systems. The cables connect all instruments, controllers, and other components of the system in parallel to the signal lines.

The eight Data I/O lines (DIO1 thru DIO8) are reserved for the transfer of data and other messages in a byte-serial, bit-parallel manner. Data and message transfer is asynchronous, coordinated by the three handshake lines: Data Valid (DAV), Not Ready For Data (NRFD), and Not Data Accepted (NDAC). The other five lines are for management of bus activity. See the figure on the right.



HP-IB Signal Lines

Devices connected to the bus may be talkers, listeners, or controllers. The controller dictates the roll of each of the other devices by setting the ATN (attention) line true and sending talk or listen addresses on the data lines. Addresses are set into each device at the time of system configuration either by switches built into the device or by jumpers on a PC board. While the ATN line is true, all devices must listen to the data lines. When the ATN line is false, only devices that have been addressed will actively send or receive data. All others ignore the data lines.

Several listeners can be active simultaneously but only one talker can be active at a time. Whenever a talk address is put on the data lines (while ATN is true), all other talkers will be automatically unaddressed.

Information is transmitted on the data lines under sequential control of the three handshake lines (DAV, NRFD and NDAC). No step in the sequence can be initiated until the previous step is completed. Information transfer can proceed as fast as devices can respond, but no faster than allowed by the slowest device presently addressed as active. This permits several devices to receive the same message byte concurrently.

The ATN line is one of the five bus management lines. When ATN is true, addresses and universal commands are transmitted on only seven of the data lines using the ASCII code. When ATN is false, any code of 8 bits or less understood by both talker and listener(s) may be used.

The IFC (interface clear) line places the interface system in a known quiescent state via the Abort message.

The REN (remote enable) line is used with the Remote, Local, and Clear Lockout/Set Local messages to select either local or remote control of each device.

Any active device can set the SRQ (service request) line true via the Require Service message. This indicates to the controller that some device on the bus wants attention, say a counter that has just completed a time-interval measurement and wants to transmit the reading to a printer.

The EOI (end or identify) line is used by a device to indicate the end of a multiple-byte transfer sequence. When a controller sets both the ATN and EOI lines true, each device capable of a parallel poll indicates its current status on the DIO line assigned to it.

In the interest of cost-effectiveness, it is not necessary for every device to be capable of responding to all the lines. Each can be designed to respond only to those lines that are pertinent to its function on the bus.

The operation of the interface is generally controlled by one device equipped to act as controller. The interface uses a group of commands to direct the other instruments on the bus in carrying out their functions of talking and listening.

The controller has two ways of sending interface messages. Multi-line messages, which cannot exist concurrently with other multi-line messages, are sent over the eight data lines and the three handshake lines. Uni-line messages are transferred over the five individual lines of the management bus.

The commands serve several different purposes:

- Addresses, or talk and listen commands, select the instruments that will transmit and accept data. They are all multi-line messages.

- Universal commands cause every instrument equipped to do so to perform a specific interface operation. They include multi-line messages and three uni-line commands: interface clear (IFC), remote enable (REN), and attention (ATN).

- Addressed commands are similar to universal commands, except that they affect only those devices that are addressed and are all multi-line commands. An instrument responds to an addressed command, however, only after an address has already told it to be talker or listener.

- Secondary commands are multi-line messages that are always used in series with an address, universal command, or addressed command (also referred to as primary commands) to form a longer version of each. Thus they extend the code space when necessary.

To address an instrument, the controller uses seven of the eight data-bus lines. This allows instruments using the ASCII 7-bit code to act as controllers. As shown in the table, five bits are available for addresses, so a total of 31 addresses are available in one byte. If all secondary commands are used to extend this into a two-byte addressing capability, 961 addresses become available (31 addresses in the second byte for each of the 31 in the first byte).

Command and Address Codes

Code Form								Meaning
X	0	0	A_5	A_4	A_3	A_2	A_1	Universal Commands
X	0	1	A_5	A_4	A_3	A_2	A_1	Listen Addresses
				except				
X	0	1	1	1	1	1	1	Unlisten Command
X	1	0	A_5	A_4	A_3	A_2	A_1	Talk Addresses
				except				
X	1	0	1	1	1	1	1	Untalk Command
X	1	1	A_5	A_4	A_3	A_2	A_1	Secondary Commands
				except				
X	1	1	1	1	1	1	1	Ignored

Code used when attention (ATN) is true (low).
X = don't care

Interface Functions

Interface functions provide the physical capability to communicate via HP-IB. These functions are defined in the IEEE Standard 488-1975. This standard, which is the designer's guide to the bus, defines each interface function in terms of state diagrams that express all possible interactions.

Bus capability is grouped under 10 interface functions, for example: Talker, Listener, Controller, Remote/Local. The following table lists the functions.

HP-IB Interface Functions

Mnemonic	Interface Function Name
SH	Source Handshake
AH	Acceptor Handshake
T	Talker (or TE = Extended Talker)*
L	Listener (or LE = Extended Listener)*
SR	Service Request
RL	Remote Local
PP	Parallel Poll
DC	Device Clear
DT	Device Trigger
C	Any Controller
C_N	A specific Controller (for example: C_A, C_B ...)
C_S	The System Controller

*Extended talkers and listeners use a two-byte address. Otherwise, they are the same as Talker and Listener.

Since interface functions are the physical agency through which bus messages are implemented, each device must implement one or more functions to enable it to send or receive a given bus message.

The following table lists the functions required to implement each bus message. Each device's operating manual lists the functions implemented by that device. Some devices, such as the 98034A Interface, list the functions implemented directly on the device.

Functions Used By Each Bus Message

Bus Message	Functions Required sender function → receiver function(s) (support functions)
Data	T→L* (SH, AH)
Trigger	C→DT* (L, SH, AH)
Clear	C→DC* (L, SH, AH)
Remote	C_S→RL* (SH, AH)
Local	C→RL* (L, SH, AH)
Local Lockout	C→RL* (SH, AH)
Clear Lockout/Set Local	C_S→RL*
Require Service	SR*→C
Status Byte	T→L* (SH, AH)
Status Bit	PP*→C
Pass Control	C_A→C_B (T, SH, AH)
Abort	C_S→T,L*C

*Since more than one device can receive (or send) this message simultaneously, each device must have the function indicated by an *

HP 9872A HP-IB Implementation

1. Functions implemented (IEEE STD 488-1975)

   a. Source Handshake (SH1)
   b. Acceptor Handshake (AH1)
   c. Talker (T2) Serial Poll
   d. Listener (L2)
   e. Service Request (SR1)
   f. No Remote Local (RL0)
   g. Parallel Poll (PP2)
   h. Device Clear (DC1)
   i. No Device Trigger (DT0)

2. Device Clear or Selected Device Clear causes the plotter to:

   a. Complete the present vector then stop with the pen up.
   b. Reset parser to expect next instruction

3. PPRN for parallel poll is assigned by the rear panel address switch. Listen addresses zero through 7 assign DIO lines 8 – 1 respectively. All other listen addresses disable parallel poll.

Plotter Default Conditions

Relative character direction	Horizontal (DR1,0)
Line type	Solid line
Line pattern length	4% of the distance from P1 to P2
Input window	Total platen area
Relative character size	0.75 X 1.5 cm
Automatic pen pickup	On
Pen velocity	36 cm/s
Adaptive pen velocity	Off
Symbol mode	Off
Tick length	.5% of |P2-P1|
Standard character set	Set 0 (Set 1 for device clear)
Alternate character set	Set 0
Character slant	0°
Mask value	223,0,0
Digitize clear	On

P1 and P2 are changed only with the initialize command (IN). They are not affected by device clear and the default command (DF).

The pen is raised by device clear.

The current pen location is moved to the lower right corner with the initialize command (IN) but is unaffected by device clear and the default command (DF).

Error Messages

error 1 — Instruction not recognized
The plotter has received an illegal character sequence.

error 2 — Wrong number of parameters
Too many or too few parameters have been sent with an instruction.

error 3 — Bad parameter
The parameters sent to the plotter with an instruction are out of range for that instruction.

error 4 — Illegal character
The character specified as a parameter is not in the allowable set for that instruction.

error 5 — Unknown character set
A character set out of the range 0 thru 4 has been designated as either the standard or alternate character set.

error 6 — Position overflow
An attempt to draw a character or perform a CP that is located outside of the plotter's numeric limit of -32768 to +32767.

Syntax and Formulas

This section lists the formal syntax for each plotter instruction.

Parameter Range Restrictions

The usable range of each parameter is listed with the syntax for each instruction.

Vector Group

Plot Absolute Instruction PA

PA X_1 coordinate, Y_1 coordinate (, X_2 coordinate, Y_2 coordinate, . . ., . . ., X_n coordinate, Y_n coordinate) [; or LF]

X and Y coordinates must be integers and are limited to the range -32768 to +32767.

Plot Relative Instruction PR

PR X_1 increment, Y_1 increment (, X_2 increment, Y_2 increment, . . ., . . ., X_n increment, Y_n increment) [; or LF]

X and Y increments must be integers and are limited to values between -32768 and +32767 referenced from the platen point 0,0.

Character Group

Designate Alternate Character Set Instruction CA

CA 0 through 4 [; or LF]

If the parameter is omitted, default value is assumed.

Character Plot Instruction CP

CP number of character space widths, number of character space heights [; or LF]

Both parameters must be within the range ±127.999. Decimal portion is optional.

Designate Standard Character Set Instruction CS

CS 0 through 4 [; or LF]

If the parameter is omitted, default value is assumed.

Absolute Direction Instruction DI

DI run, rise [; or LF]

Both parameters must be in the range of ±127.999. If the parameters are omitted, default values are assumed.

Relative Direction Instruction DR

DR % run, % rise [; or LF]

Both parameters must be in the range of ±127.999. If the parameters are omitted, default values are assumed.

Label Instruction LB

LB any combination of text, expressions, or string variables [ETX]

Select Alternate Set Instruction SA

SA [; or LF]

Parameters are not used.

Absolute Character Size Instruction SI

SI width, height [; or LF]

Both parameters must be in the range of ±127.999. If the parameters are omitted, default values are assumed.

Character Slant Instruction SL

SL decimal number [; or LF]

Decimal number must be in the range of ±127.999. If the parameter is omitted, default value is assumed.

Relative Character Size Instruction SR

SR % width, % height [; or LF]

Both parameters must be in the range of ±127.999. If the parameters are omitted, default values are assumed.

Select Standard Character Set Instruction SS

SS [; or LF]

Parameters are not used.

User Defined Character Instruction UC

UC (pen control parameter,) X increment, Y increment,
(pen control parameter,) X increment, Y increment,
. . . . [; or LF]

Pen control parameter must be an integer
+99 = pen down
-99 = pen up

X and Y increments can range from -98 to +98 character grid units.

Line Type Group

Line Type Instruction LT

LT pattern number, pattern length [; or LF]

The range of pattern number is 0 through 6 and the range of pattern length is ±127.999. If the parameters are omitted, default values are assumed.

Pen Instructions PD and PU

PD [; or LF]

or

PU [; or LF]

Parameters are not used.

Symbol Mode Instruction SM

SM character [; or LF]

Character is limited to the centered characters of the character set chosen. If the parameter is omitted, default value is assumed.

Pen Select Instruction SP

SP pen number [; or LF]

The range of the pen number is 0 through 4.

The Adaptive Pen Velocity Instruction VA

VA [; or LF]

Parameters are not used.

Normal Velocity Instruction VN

VN [; or LF]

Parameters are not used.

Velocity Select Instruction VS

VS 1 through 36; pen number [; or LF]

The pen velocity must be an integer in the range of 1 through 36. The pen number an integer in the range 1 through 4. If no parameters are specified, default values are assumed.

Digitize Group

Digitize Clear Instruction DC

DC [; or LF]

Parameters are not used.

Digitize Point Instruction DP

DP [; or LF]

Parameters are not used.

Output Current Position and Pen Status Instruction OC

OC [; or LF]

Parameters are not used.

The Output Digitized Point and Pen Status Instruction OD

OD [; or LF]

Parameters are not used.

Axes Group

Tick Length Instruction TL

TL tp, tn [; or LF]

Both parameters must be in the range of ±127.999. If the parameters are omitted, default values are assumed.

Tick Instructions XT and YT

XT [; or LF]

or

YT [; or LF]

Parameters are not used.

Setup Group

Input P1 and P2 Instruction IP

IP $P1_X$, $P1_Y$, $P2_X$, $P2_Y$ [; or LF]

Parameters must be in the range of -32768 to +32767. If the parameters are omitted, default values are assumed.

Input Window Instruction IW

IW X lower left, Y lower left, X upper right, Y upper right [; or LF]

X parameters must be in the range of 0 to +16000 and Y parameters must be in the range of 0 to +11400.

Output P1 and P2 Instruction OP

OP [; or LF]

Parameters are not used.

Configuration Status Group

Automatic Pen Pickup Instruction AP

AP [; or LF]

Parameters are not used.

Default Instruction DF

DF [; or LF]

Parameters are not used.

The Input Mask Instruction IM

IM E-mask value, S-mask value, P-mask value [; or LF]

The sum of the parameters must be in the range of 0 through 255. If the parameters are omitted, default values are assumed.

Initialize Instruction IN

IN [; or LF]

Parameters are not used.

Output Error Instruction OE

OE [; or LF]

Parameters are not used.

Output Status Instruction OS

OS [; or LF]

Parameters are not used.

ASCII Character Codes

Binary is often used as a code to represent not only numbers, but also alphanumeric characters such as "A" or "," or "?" or "x" or "2". One of the most common binary codes used is ASCII[1]. ASCII is an eight-bit code, containing seven data bits and one parity bit. The plotter uses ASCII for most I/O operations. No parity bit is used. For example:

Character	ASCII Binary Code	ASCII Decimal Code
A	01000001	65
B	01000010	66
?	00111111	63

A complete list of ASCII characters and their octal and decimal representations is given next.

[1] American Standard Code for Information Interchange.

Plotter ASCII Code Definitions

Decimal Code	ASCII Character	9872A Function/Character Set				
		Set Ø	Set 1	Set 2	Set 3	Set 4
0	NULL	Error 4 Generated				
1	SOH	Error 4 Generated				
2	STX	Error 4 Generated				
3	ETX	End Label Instruction				
4	ETO	Error 4 Generated				
5	ENQ	Error 4 Generated				
6	ACK	Error 4 Generated				
7	BEL	No Operation (NOP)				
8	BS	Backspace				
9	HT	NOP				
10	LF	Line Feed				
11	VT	Inverse Line Feed				
12	FF	NOP				
13	CR	Carriage Return				
14	SO	Select Alternate Character Set				
15	SI	Select Standard Character Set				
16	DLE	Error 4 Generated				
17	DC1	NOP				
18	DC2	NOP				
19	DC3	NOP				
20	DC4	NOP				
21	NAK	Error 4 Generated				
22	SYN	Error 4 Generated				
23	ETB	Error 4 Generated				
24	CAN	Error 4 Generated				
25	EM	Error 4 Generated				
26	SUB	Error 4 Generated				
27	ESC	Error 4 Generated				
28	FS	Error 4 Generated				
29	GS	Error 4 Generated				
30	RS	Error 4 Generated				
31	US	Error 4 Generated				
32	SP	Space				
33	!	!	!	!	!	!
34	"	"	"	"	"	"
35	#	#	#	£	£	¿
36	$	$	$	$	$	$
37	%	%	%	%	%	%
38	&	&	&	&	&	&
39	'	'	'	'	'	'
40	(	(	(	(	(	(
41	)	)	)	)	)	)
42	*	*	*	*	*	*
43	+	+	+	+	+	+
44	,	,	,	,	,	,
45	–	–	–	–	–	–
46	.	.	.	.	.	.
47	/	/	/	/	/	/
48	Ø	Ø	Ø	Ø	Ø	Ø
49	1	1	1	1	1	1
50	2	2	2	2	2	2
51	3	3	3	3	3	3
52	4	4	4	4	4	4

NOTE: Characters offset to the left have the automatic backspace feature.

Plotter ASCII Code Definitions (Continued)

Decimal Code	ASCII Character	9872A Function/Character Set				
		Set Ø	Set 1	Set 2	Set 3	Set 4
53	5	5	5	5	5	5
54	6	6	6	6	6	6
55	7	7	7	7	7	7
56	8	8	8	8	8	8
57	9	9	9	9	9	9
58	:	:	:	:	:	:
59	;	;	;	;	;	;
60	<	<	<	<	<	<
61	=	=	=	=	=	=
62	>	>	>	>	>	>
63	?	?	?	?	?	?
64	@	@	@	@	@	@
65	A	A	A	A	A	A
66	B	B	B	B	B	B
67	C	C	C	C	C	C
68	D	D	D	D	D	D
69	E	E	E	E	E	E
70	F	F	F	F	F	F
71	G	G	G	G	G	G
72	H	H	H	H	H	H
73	I	I	I	I	I	I
74	J	J	J	J	J	J
75	K	K	K	K	K	K
76	L	L	L	L	L	L
77	M	M	M	M	M	M
78	N	N	N	N	N	N
79	O	O	O	O	O	O
80	P	P	P	P	P	P
81	Q	Q	Q	Q	Q	Q
82	R	R	R	R	R	R
83	S	S	S	S	S	S
84	T	T	T	T	T	T
85	U	U	U	U	U	U
86	V	V	V	V	V	V
87	W	W	W	W	W	W
88	X	X	X	X	X	X
89	Y	Y	Y	Y	Y	Y
90	Z	Z	Z	Z	Z	Z
91	[	[	[	[	Ø	[
92	\	\	ſ	ç	Æ	¡
93	]	]	]	]	ø	]
94	^	^	↑	^	æ	^
95	_	_	_	_	_	_
96	`	`	`	`	`	`
97	a	a	a	a	a	a
98	b	b	b	b	b	b
99	c	c	c	c	c	c
100	d	d	d	d	d	d
101	e	e	e	e	e	e
102	f	f	f	f	f	f
103	g	g	g	g	g	g
104	h	h	h	h	h	h
105	i	i	i	i	i	i
106	j	j	j	j	j	j
107	k	k	k	k	k	k

Plotter ASCII Code Definitions (Continued)

Decimal Code	ASCII Character	9872A Function/Character Set				
		Set Ø	Set 1	Set 2	Set 3	Set 4
108	l	l	l	l	l	l
109	m	m	m	m	m	m
110	n	n	n	n	n	n
111	o	o	o	o	o	o
112	p	p	p	p	p	p
113	q	q	q	q	q	q
114	r	r	r	r	r	r
115	s	s	s	s	s	s
116	t	t	t	t	t	t
117	u	u	u	u	u	u
118	v	v	v	v	v	v
119	w	w	w	w	w	w
120	x	x	x	x	x	x
121	y	y	y	y	y	y
122	z	z	z	z	z	z
123	{	{	π	¨	¨	~
124	¦	¦	⊢	°	°	~
125	}	}	→	¨	¨	~
126	~	~	~	'	°	~
127	DEL	Error 4 Generated				

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