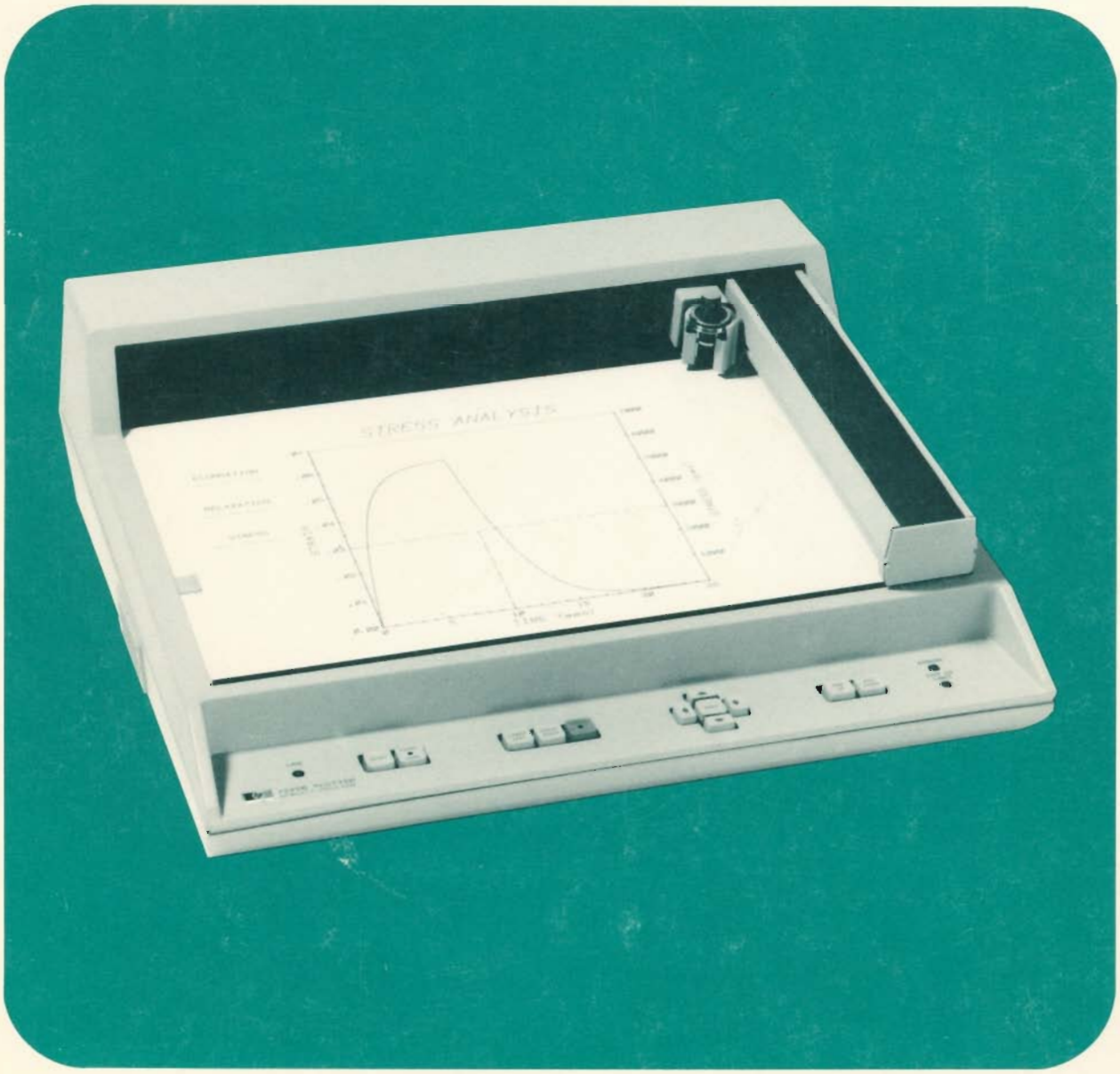
Hewlett-Packard 7225B Graphics Plotter
17601A Option 001, 035, 045, and 085 Personality Module
Operating and Programming Manual
Using HP-GL Instructions

DESIGNED FOR HP-IB SYSTEMS



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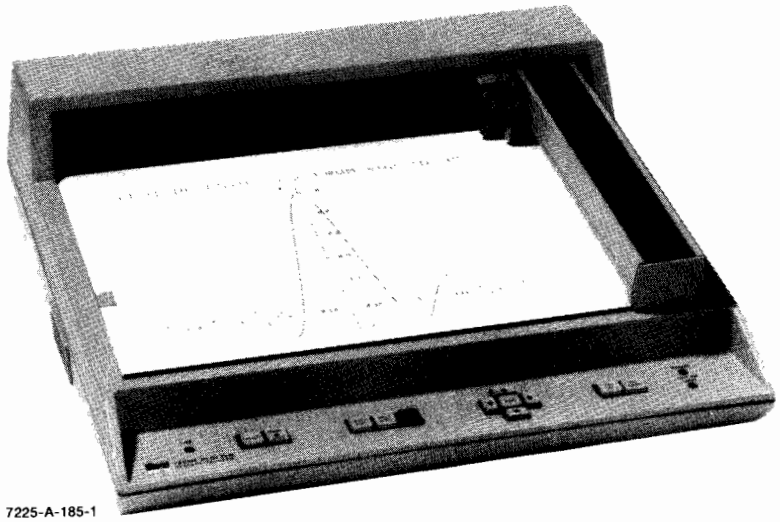


7225-A-185-1

HP 7225B GRAPHICS PLOTTER

16399 W. Bernardo Drive, San Diego, California 92127

August 1981

Manual Summary

Chapter 1: General Information

Information about setting up the plotter and an overview of the physical and operating characteristics of the plotter.

Chapter 2: Plotter/Computer Communication

Summarizes the interfacing requirements of the plotter and includes the methods of addressing, sending, and receiving data over the Hewlett-Packard Interface Bus.

Chapter 3: General Programming Instructions

Describes the plotter's instruction set, default conditions, and general output instructions.

Chapter 4: Scaling

Decribes the instructions for locating the scaling points and includes the scaling instruction.

Chapter 5: Plotting

Describes the instructions used in plotting.

Chapter 6: Labeling Plots

Describes the instructions used in labeling. Included are instructions to vary the size, width, and slant of the characters as well as instructions for character set selection and label positioning.

Chapter 7: Plot Enhancement

Describes the instructions used to enhance the plot.

Chapter 8: Digitizing

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

Manual Summary (Continued)

Chapter 9: Putting The Commands To Work

A step-by-step example illustrating the procedures to follow in order to draw and label and plot data using the 7225 instructions.

Appendix A

Provides an overview of the Hewlett-Packard Interface Bus (HP-IB)

Appendix B

Included are some number system conversions, scaling equations, default conditions, NOP instructions, a summary of the instruction syntax, error message definition and ASCII codes.

Table of Contents

Chapter 2 (Continued)

Chapter 6 (Continued)

Chapter 1
General Information

Introduction

This manual contains interfacing and programming information for the Hewlett-Packard 7225 Graphics Plotter. The manual is organized into nine chapters and two appendices as follows:

Chapter 1 — General Information
Chapter 2 — Plotter/Computer Communication
Chapter 3 — General Programming Instructions
Chapter 4 — Scaling
Chapter 5 — Plotting
Chapter 6 — Labeling Plots
Chapter 7 — Plot Enhancement
Chapter 8 — Digitizing
Chapter 9 — Putting The Commands To Work
Appendix A
Appendix B

Before using this manual, you should be thoroughly familiar with your computer 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.
necessary parameter	— All typeset items are required parameters, if command is to be used with parameters.
( )	— All items in parenthesis are optional.
[;or LF]	— Required terminator.

The following convention applies to program listings.

*	— An asterisk preceding a program line number indicates that line may require a controller-dependent format statement in order to be accepted by the plotter.

Description

The Hewlett-Packard 7225B with the 17601A Personality Module is a microprocessor-based HP-IB plotter that produces high quality graphic plots on any size chart up to 210 × 297 mm (ISO A4). The 7225 offers exceptional line and character quality with moves as small as 0.032 mm (0.00125 in.). Thirty-nine different instructions are built in to equip the plotter with such capabilities as point digitizing, labeling, character sizing, scaling, and window plotting. The 7225 is interfaced through the Hewlett-Packard Interface Bus (conforms to ANSI/IEEE 488-1978). 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.

High quality plotting, with programmable pen velocity which ranges from 10 mm/s to 250 mm/s, makes it possible to produce distinctive graphics not only on standard paper, but also on other media. An optional overhead transparency kit enables you to produce high quality graphic transparencies from your plotting programs.

Seven different dashed-line fonts, symbol mode plotting, and user-defined characters aid in trace identification.

Character plotting speed of up to three characters per second enables you to produce fully lettered graphs quickly. Annotation can be easily done using any of five character sets, including three European sets.

The 7225 is designed to be especially useful in the areas of business graphics, statistics, medicine, numerical control, surveying, and engineering design. Whether data is tabulated, measured, or computed, the 7225 enables you to quickly prepare plots of excellent line quality and high resolution.

Unpacking and Inspection

The individual parts of your plotter were thoroughly inspected before the unit was shipped to you, and the instrument should be in good operating order. Carefully inspect the plotter and accessories for any physical damage sustained in transit. Notify the nearest HP sales and service office or your authorized HP-85 dealer and file a claim with the carrier if the unit is received in a damaged condition.

CAUTION

When unpacking and handling the plotter, always be sure to restrain the pen arm if the plotter must be tilted. When power is not applied to the plotter, the pen arm slides freely and may hit the opposite platen edge, resulting in possible damage or arm misalignment.

Please check to ensure that you have received all of the items that should accompany the plotter. Refer to the table of Accessories Supplied and check that all accessories are present. If you have any difficulties with the plotter, if it is not operating properly, or if accessories are missing, contact the nearest HP sales and service office, or your authorized HP-85 dealer.

Retain the original packing materials and carton. If the plotter must be shipped, this will save having to order new packing materials and a carton.

Accessories Supplied

The following items are supplied with each 7225 equipped with 17601A Option 001, Option 035, Option 045, or Option 085:

ITEM	QUANTITY	PART NUMBER
Operating and Programming Manual	1	17601-90006
7225/HP-85 Programming Guide*	1	07225-90007
Graph Paper—8½ × 11-inch	1 pad	9280-0475
Pens; package of 5 black pens, 0.3 mm line width	1	5060-6787
Pens; package of 1 each; red, blue, green, black; 0.3 mm line width	1	5060-6810
Power cord (appropriate cord supplied, based on origin of sales order)	1	—
Dust Cover	1	9222-0635

*Supplied with Option 085 only.

Accessories Available

The following items are available and can be purchased using the appropriate part number:

7225B OPTION NUMBER	ITEM	PART NUMBER
006	Supplies Kit, ISO A4 paper size	—
007	Supplies Kit, 8½ × 11-inch paper size	—
010	Vinyl Carrying Case (not suitable for shipping plotter)	1540-0560
—	Digitizing Sight	09872-60066
—	Plotter Pens, fiber tip	
	Package of 5 red pens, 0.3 mm line width	5060-6784
	Package of 5 red pens, 0.7 mm line width	5060-6893
	Package of 5 blue pens, 0.3 mm line width	5060-6785
	Package of 5 blue pens, 0.7 mm line width	5060-6891
	Package of 5 green pens, 0.3 mm line width	5060-6786

Accessories Available (Continued)

7225B OPTION NUMBER	ITEM	PART NUMBER
—	Plotter Pens, fiber tip (continued)	
	Package of 5 green pens, 0.7 mm line width	5060-6892
	Package of 5 black pens, 0.3 mm line width	5060-6787
	Package of 5 black pens, 0.7 mm line width	5060-6890
	Four-color Pack, 0.3 mm line width, 1 each red, green, blue, black	5060-6810
	Four-color Pack, 0.7 mm line width, 1 each red, green, blue, black	5060-6858
	Six-color Pack, 0.3 mm line width, 1 each burnt orange, lime green, gold, turquoise, violet, brown	5060-6894
	Six-color Pack, 0.7 mm line width, 1 each burnt orange, lime green, gold, turquoise, violet, brown	5060-6895
—	Plotter Paper, gridded	
	Box:	
	English, 8½ × 11-in., 7 × 10 in. grid area, 10 grids/in., 100 sheets	9270-1006
	Metric, 216 × 280 mm, 180×250 mm grid area, 1 grid/mm, 100 sheets	9270-1023
—	Plotter Paper, gridless	
	Pad:	
	50 sheets 8½ × 11 in.	9280-0475
	50 sheets ISO A4 (210 × 297 mm)	9280-0476
	Package:	
	300 sheets 8½ × 11 in.	9280-0517
	300 sheets ISO A4 (210×297 mm)	9280-0519
—	Overhead Transparency Kit (includes)	17055A
	4 pens (black, red, blue, green) 0.3 mm line width	5060-6818
	4 pens (black, red, blue, green) 0.6 mm line width	5060-6819
	4 pens (black, orange, brown, violet) 0.3 mm line width	5060-6834
	4 pens (black, orange, brown, violet) 0.6 mm line width	5060-6835
	Solvent 29.6 ml (1 fl. oz.)	5060-6828
	100 sheets transparency film (kit includes 2 packages)	9270-0639

Accessories Available (Continued)

7225B OPTION NUMBER	ITEM	PART NUMBER
—	Overhead Transparency Pens, single-color packages	
	Package of 5 black pens, 0.3 mm line width	5061-5010
	Package of 5 black pens, 0.6 mm line width	5061-5020
	Package of 5 red pens, 0.3 mm line width	5061-5012
	Package of 5 red pens, 0.6 mm line width	5061-5022
	Package of 5 green pens, 0.3 mm line width	5061-5015
	Package of 5 green pens, 0.6 mm line width	5061-5025
	Package of 5 blue pens, 0.3 mm line width	5061-5016
	Package of 5 blue pens, 0.6 mm line width	5061-5026
—	Interface Cables, ROMs, and Software (see your HP sales representative), or your authorized HP-85 dealer	
—	7225B Service Manual*	07225-90006
—	17601A Service Manual*	17601-90003

*available for qualified service personnel only.

Additional plotter supplies are available from your local Hewlett-Packard sales and service office, or authorized HP-85 dealer. Just ask for a copy of the Computer Supplies Catalog which is a complete listing of supplies for Hewlett-Packard computers and plotters.

Grounding Requirements

To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the plotter be properly grounded. The plotter is equipped with a three-conductor power cable which, when connected to an appropriate power receptacle, grounds the plotter. To preserve this protection feature, do not operate the plotter from an ac power outlet which has no ground connection.

Power Requirements

The 7225 Plotter has the following power requirements:

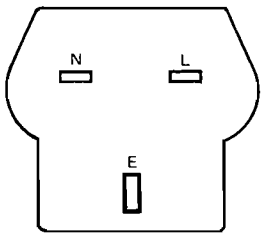
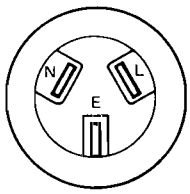
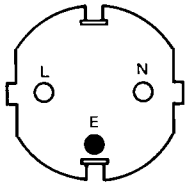
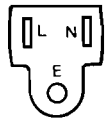
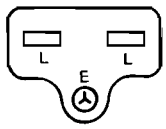
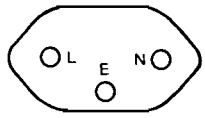
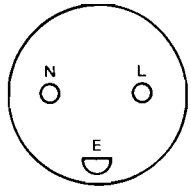
- Line Voltage: 100 V~ (ac) +5%, −10%
  120 V~ (ac) +5%, −10%
  220 V~ (ac) +5%, −10%
  240 V~ (ac) +5%, −10%
- Line Frequency: 48 to 66 Hertz
- Line Current: 1A @ 100V
  1A @ 120V
  500 mA @ 220V
  500 mA @ 240V

Line Voltage Selection

The 7225 is shipped from the factory with the line voltage set as required by the option number ordered (001, 100V; 002, 120V; 003, 220V; 004, 240V). If the option number is not specified, the line voltage is set to the nominal value for the specified area. A decal located on the rear panel identifies the line voltage selected for the plotter. The line voltage can be changed by qualified personnel only. Line voltage selection procecures are contained in the 7225B Service Manual, HP part number 07225-90006.

Power Cords

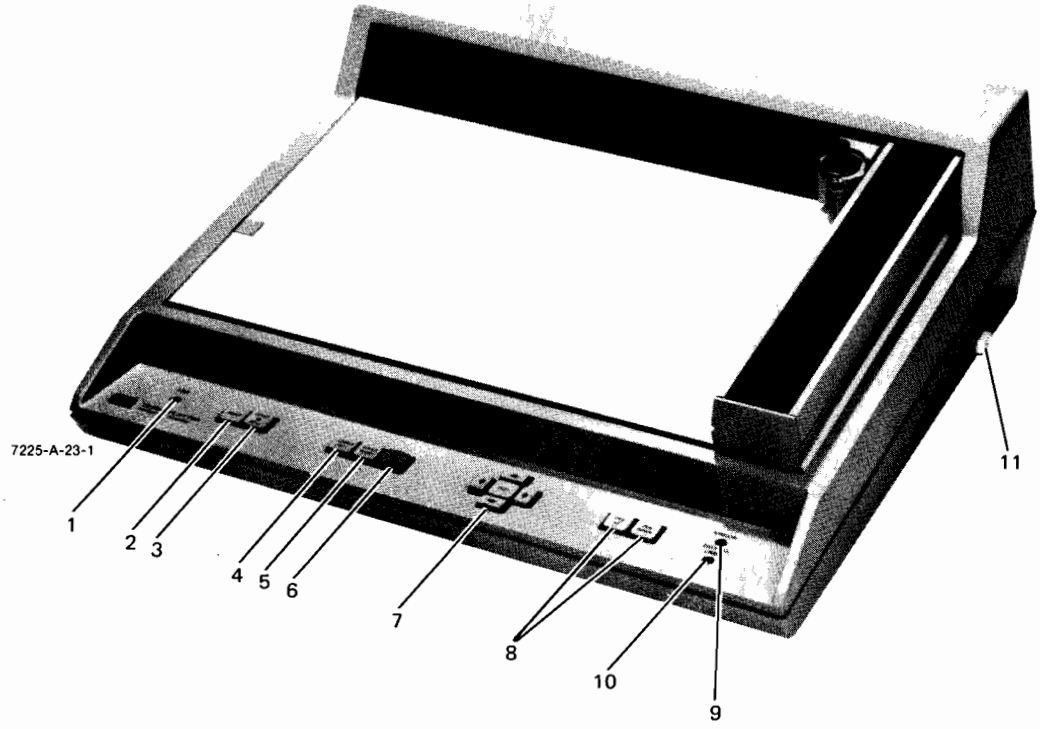
Power cords with different plugs are available for the 7225. The cord packaged with each instrument depends upon its destination. The power cords supplied by HP have polarities matched to the power-input socket in the plotter as shown in the accompanying chart. If your instrument has the wrong power cord for your area, please contact your local HP sales and service office, or your authorized HP-85 dealer.

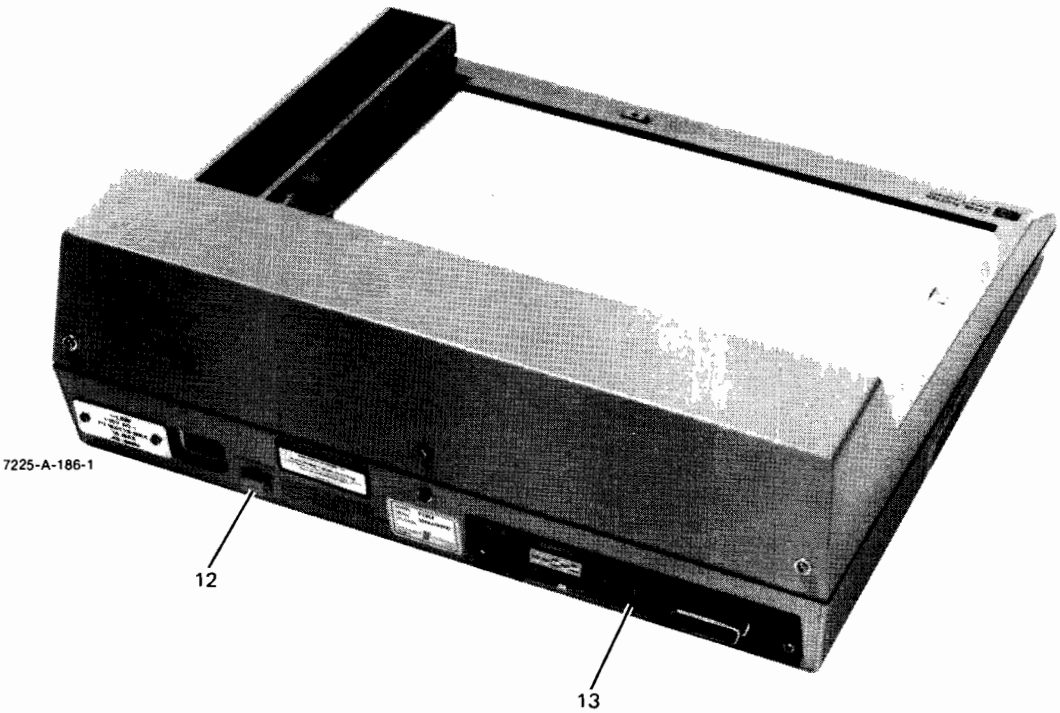
		Option No.
BS 1363A 	HP Part Number 8120-1351; 250 V, 13A, 1 ϕ plug rating. For use in United Kingdom, Cyprus, Nigeria, Rhodesia, Singapore.	900
AS C112 	HP Part Number 8120-1369; 250 V, 10 A, 1 ϕ plug rating. For use in Australia, New Zealand.	901
CEE 7-VII 	HP Part Number 8120-1689; 250 V, 10/16 A, 1 ϕ plug rating. For use in East and West Europe, Saudia Arabia, Egypt, South Africa, India.	902
NEMA 5-15P 	HP Part Number 8120-1378; 125 V, 15 A, 1 ϕ plug rating. For use in Canada, Japan, Mexico, Philippines, Taiwan, UL approved in United States.	903
NEMA 6-15P 	HP Part Number 8120-0698; 250 V, 15 A, 1 ϕ plug rating. For use in Canada, UL approved in United States.	904
SEV 1011 	HP Part Number 8120-2104; 250 V, 10 A, 1 ϕ plug rating. For use in Switzerland.	906
DHCK-107 	HP Part Number 8120-2956; 250 V, 10 A, 1 ϕ plug rating. For use in Denmark.	912

NOTE: All plugs are viewed from connector end.

- = L Line or Active Conductor (also called "live" or "hot")
- = N Neutral or Identified Conductor
- = E Earth or Safety Ground

1-18-A-2





7225 Plotter Controls and Indicators

Controls and Indicators

A brief description of the 7225 controls and indicators and their functions follows:

1. 

An indicator lamp that is on when source AC power is applied to the instrument.

2. 

A pushbutton control which functions as follows:

a. When pressed, the pen lifts (if it was down), moves to the chart load position (extreme upper right) momentarily, then returns to the last position held prior to pressing the pushbutton. If the pen was down when [RESET] was pressed, the pen is lowered after returning to the final location. Scaling points [LOWER LEFT] and [UPPER RIGHT] remain at their previously established locations.

b. When [ENTER •] is pressed, followed by [RESET], the pen lifts (if it was down), moves to the chart load position and remains there with the pen up. Scaling points [LOWER LEFT] and [UPPER RIGHT] are reset to default values. See Setting The Scaling Points, Chapter 1.

c. If the pen has been accidentally bumped or otherwise forced off its present position, pressing [RESET] will cause the pen to go through a reset cycle, then return to its last specified position.

NOTE

If the ERROR and/or OUT OF LIMITS lamps are on, pressing [RESET] or [ENTER •] [RESET]. [RESET] will not extinguish the lamps or reset the error and/or out of limits conditions.

---

d. Pressing [RESET] during program execution will cause the program to halt, the pen to go through a reset cycle, then continue program execution. If [RESET] is pressed and held down during program execution, the pen will reset, return to its last commanded position, and halt the program until released.

3. 

A pushbutton switch and lamp used to load chart paper. When pressed, the following occurs.

a. CHART LOAD pushbutton lamp is on steady.

b. Electrostatic paper hold-down deactivates.

c. The pen lifts (if it was down) and moves to the upper right mechanical limits of the platen.

d. When pressed with the lamp on steady, the electrostatic paper hold-down activates and the lamp extinguishes.

e. Pressing CHART LOAD during program execution lights the lamp, lifts and moves the pen to the upper right mechanical limits, and deactivates the electrostatic paper hold-down. Pressing CHART LOAD again extinguishes the lamp, allows the pen to move to the position commanded at the present step in the program, and activates the electrostatic paper hold-down. Plot data are lost during the time the pen moves to, remains at, and returns from the chart load position.

f. The CHART LOAD lamp is momentarily lighted at the start of the confidence test.

4. 

A pushbutton switch used to lift the pen and move it to the current lower left scaling point.

Pressing ENTER followed by LOWER LEFT enters the current pen position as the new lower left scaling point. The ENTER lamp extinguishes upon completion of this function.

5. 

A pushbutton switch used to lift the pen and move it to the current upper right scaling point.

Pressing ENTER followed by UPPER RIGHT enters the current pen position as the new upper right scaling point. The ENTER lamp extinguishes upon completion of the function.

6. 

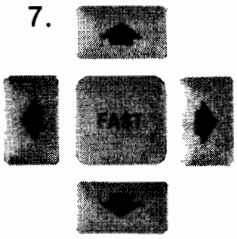
A multipurpose control which is used to perform the following:

a. Used with [RESET] to perform a power-up initialization sequence as when the power is first turned on.

b. Used with [LOWER LEFT] and [UPPER RIGHT] to establish scaling points.

c. The ENTER control can be cleared by pressing any other pushbutton except [PEN UP] or [PEN DOWN]. Receipt of plot data will also clear the ENTER control. However, it is recommended that an ENTER be cleared by pressing the [FAST] pushbutton. This avoids any pen movement or parameter resets that may occur with other pushbuttons.

d. The ENTER lamp is momentarily lighted at the start of the confidence test.

7. 

Pushbutton switches used to move the pen within the plotting area as follows:

a. Pressing an arrow pushbutton moves the pen in the direction of the arrow at approximately 4 mm/s.

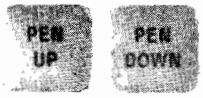
b. Pressing an arrow pushbutton together with the [FAST] pushbutton moves the pen in the direction of the arrow at approximately 60 mm/s.

c. Pressing two adjacent arrow pushbuttons moves the pen at a 45° diagonal between the two arrow directions.

d. Pressing two opposite arrow pushbuttons produces no pen movement in that axis.

7. (Continued)

e. Pressing an arrow pushbutton during program execution halts the program and moves the pen in the direction of the arrow as long as the pushbutton is held down. If the pen is down when the arrow button is pressed, a line will be drawn. Pressing the [FAST] pushbutton halts the program as long as the pushbutton is held down.

8. 

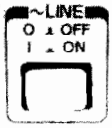
Pushbutton controls that are used to raise or lower the pen. When pressed and held down during program execution, the pushbutton will override programmed pen control until released.

9. 

An error lamp that lights when an error occurs if the error mask has been set to flag that error. (See Input Mask Instruction, Chapter 3). The ERROR lamp is momentarily lighted at the start of the confidence test.

10. 

An indicator lamp that is used to signify an out of limits condition. The OUT OF LIMIT lamp is momentarily lighted at the start of the confidence test.

11. 

A pushbutton switch that controls application of power to the plotter. Power is off when set to O⏚ and on when set to I⏦.

12. 

A pushbutton switch that initiates the confidence test. (See Running The Confidence Test, Chapter 1.)

13. 

The 17601A personality module which incorporates a 24-pin connector for interfacing the computer with the plotter, the plotter address switch and the listen only switch. (See Chapter 2.)

Setting Up the Plotter

Turning the Power On

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

a. Pen moves to upper right corner and remains raised.
b. Electrostatic hold-down is activated.
c. Certain parameters are set to their default values. For a description, see the IN and DF instructions (Chapter 3).
d. LINE lamp on front panel turns on.

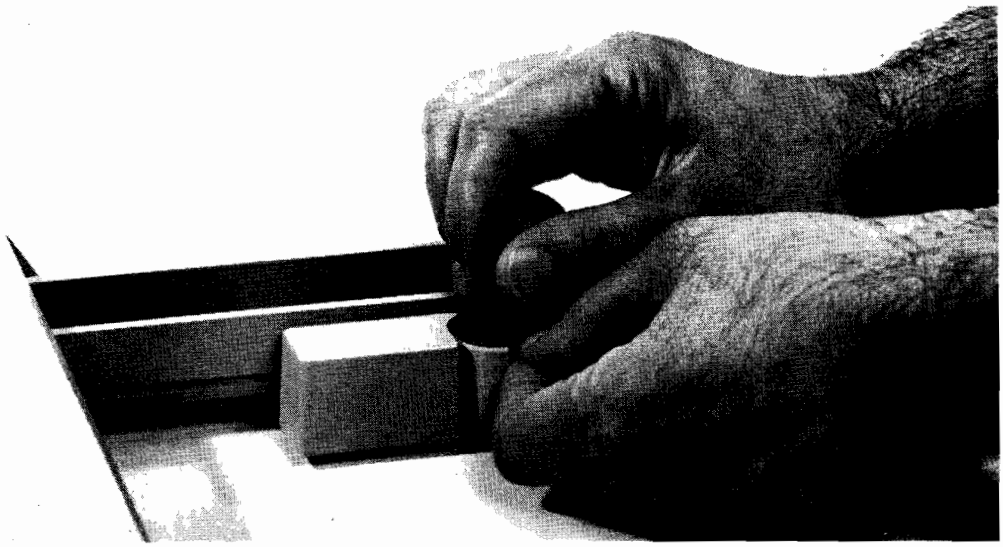
Loading the Pen

After the plotter's initialization process is complete and the plotter arm has stopped moving, you can install the pen as follows:

a. Select the pen, uncap it, and place it in the pen holder.
b. While supporting the ring under the pen holder with an index finger, gently press down on the pen until it snaps into position. Do not press on the point of the pen as this can reduce its drawing accuracy.

NOTE

Always remove and cap the pens when not in use.



Installing The Pen

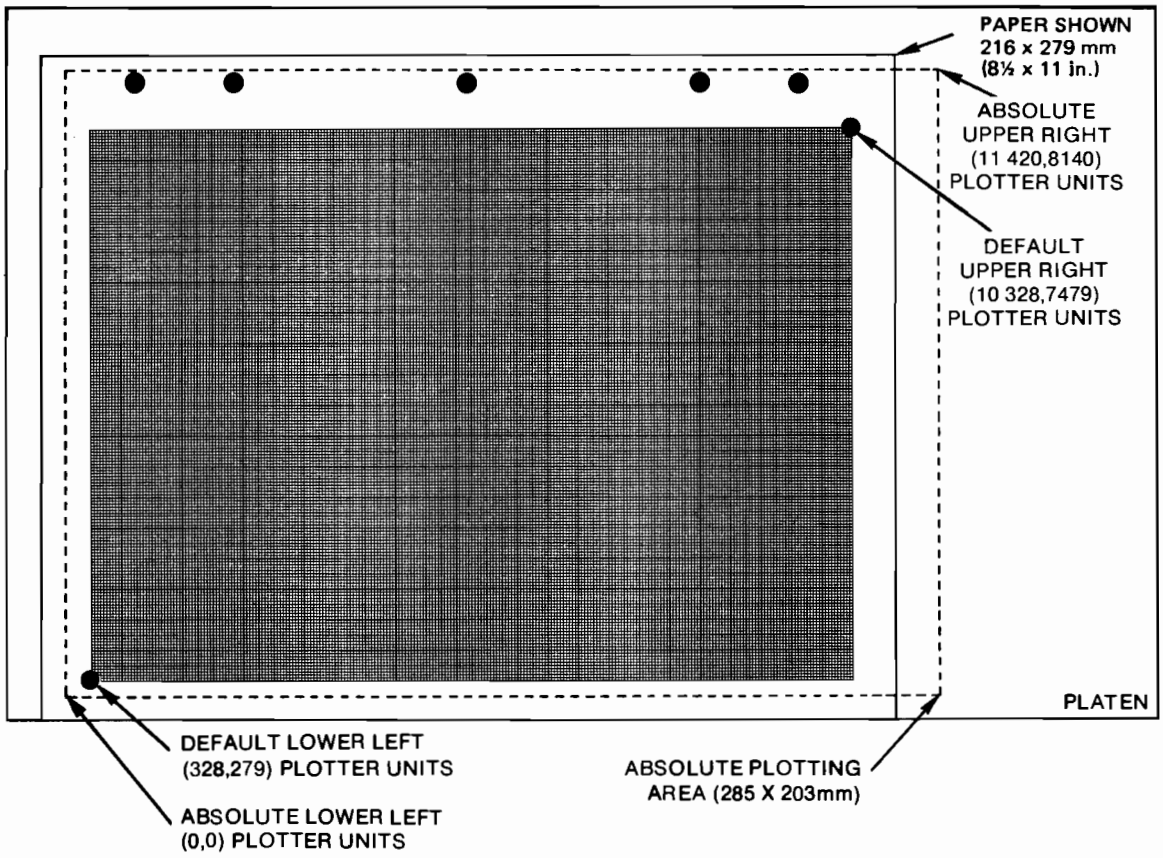
Loading Paper

To load paper, you first press CHART 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 the paper out using the back of your hand so that skin oil from your fingertips is not deposited on the paper. Make sure that the paper is positioned squarely against the ridge at the bottom of the platen. Now press CHART LOAD again. This will activate the paper hold-down mechanism and turn off the lamp in CHART LOAD. Smooth the paper again with the back of your hand.

This plotter is designed to be used with HP paper and pens. Use of other paper may cause poor line quality. Paper which is too absorbent will cause lines to feather; paper which is too slick will not allow ink to adhere properly. Pen life may be shortened due to the abrasive nature of some paper, and pen tips will clog if used with paper that is too fibrous. Certain coated papers result in dull colors. For best results, order papers listed under Accessories Supplied (Chapter 1), or listed in the HP Computer Supplies catalog, or in literature available from your authorized HP-85 dealer.

Setting the Scaling Points

Scaling points may be set using front panel controls [ENTER] [LOWER LEFT] and [ENTER] [UPPER RIGHT] When the plotter is turned on, default scaling points are set as shown in the following illustration:



Scaling points can be relocated using plotter front panel controls as follows:

a. Move the pen to the desired lower left position using [FAST]

b. Press [ENTER] . The lamp will start blinking. Press [LOWER LEFT] . The lamp will go out.

c. Move the pen to the desired upper right position using the pen position control pushbuttons.

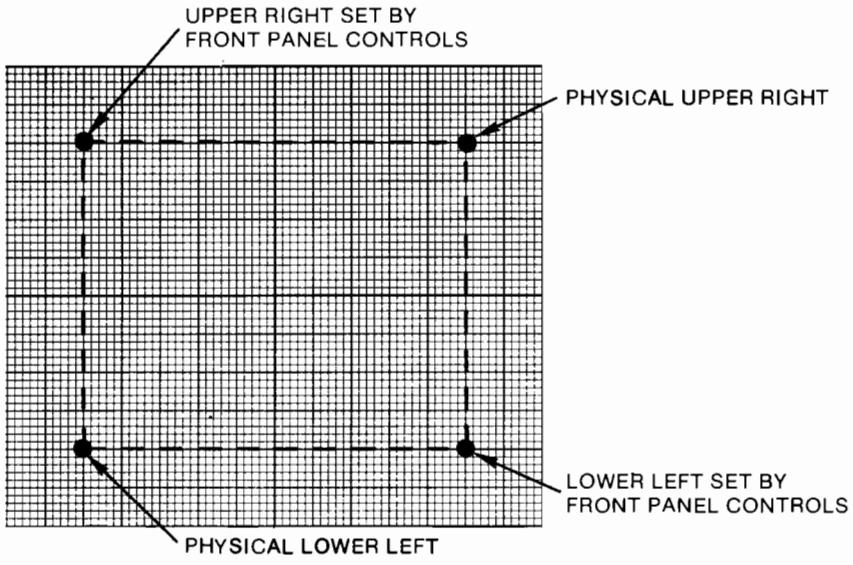
d. Press [ENTER] . The lamp will start blinking. Press [UPPER RIGHT] . The [ENTER] lamp will go out.

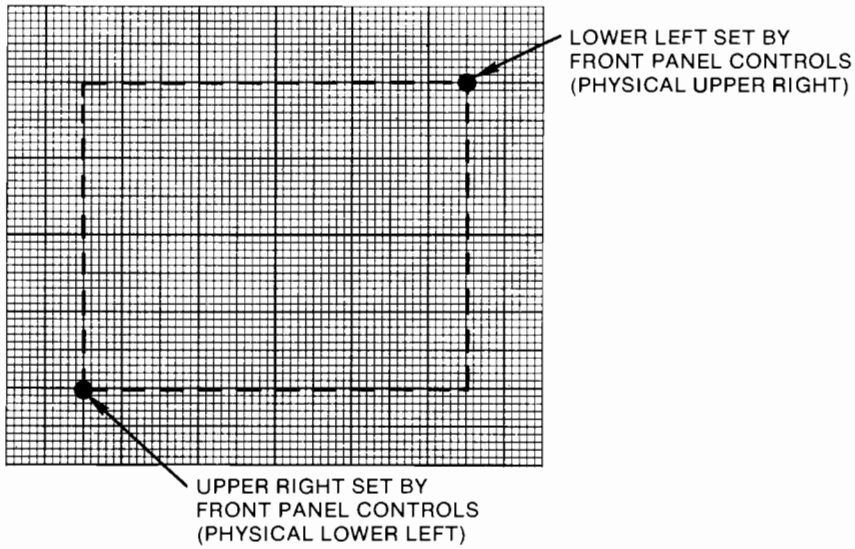
These manually entered lower left and upper right positions are stored as the new scaling points, replacing the previously set limits. To check the new points:

a. Press [LOWER LEFT] . The pen should move to the new lower left position.

b. Press [UPPER RIGHT] . The pen should move to the new upper right position.

Lower left and upper right as set by the plotter front panel controls do not need to have a true lower left/upper right relationship. They may occupy opposite corners of any desired plotting area. Refer to the following examples for clarification:





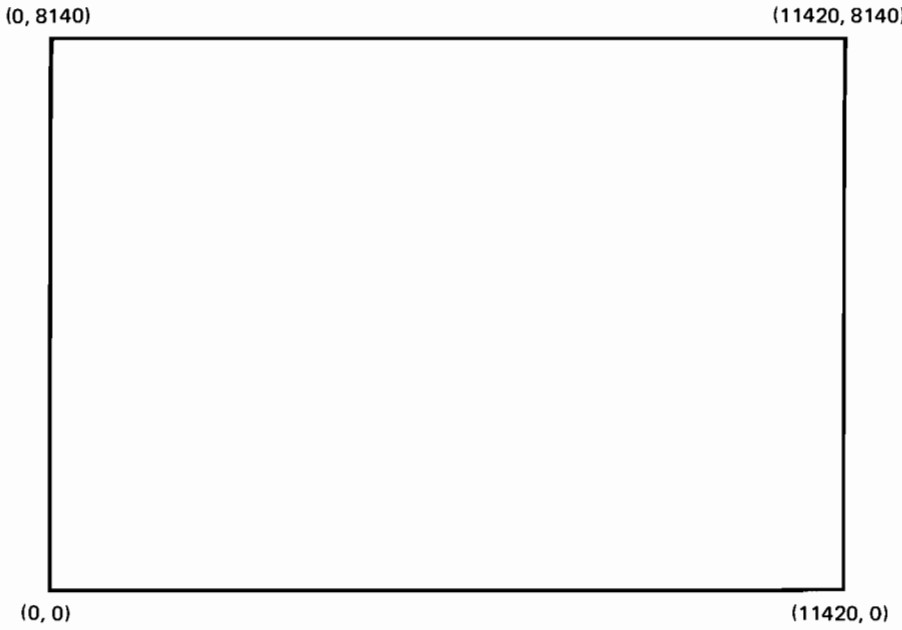
Scaling points may also be set programmatically by executing an IP instruction (See Chapter 4).

Unit Systems

The plotting area can be described, for purposes of plotting, using two types of units; plotter units, and user units. The physical size of the plotting area on the platen is 203 x 285 mm (8 x 11.2 in.).

The Plotter Unit

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



Absolute Plotting Area Scale (Mechanical Limits)

When the plotter is initialized by power-up, front panel buttons, or use of the IN instruction, scaling points [LOWER LEFT] (P1) and [UPPER RIGHT] (P2) are set to the points $P1_X = 328$, $P1_Y = 279$, $P2_X = 10328$, and $P2_Y = 7479$ plotter units.

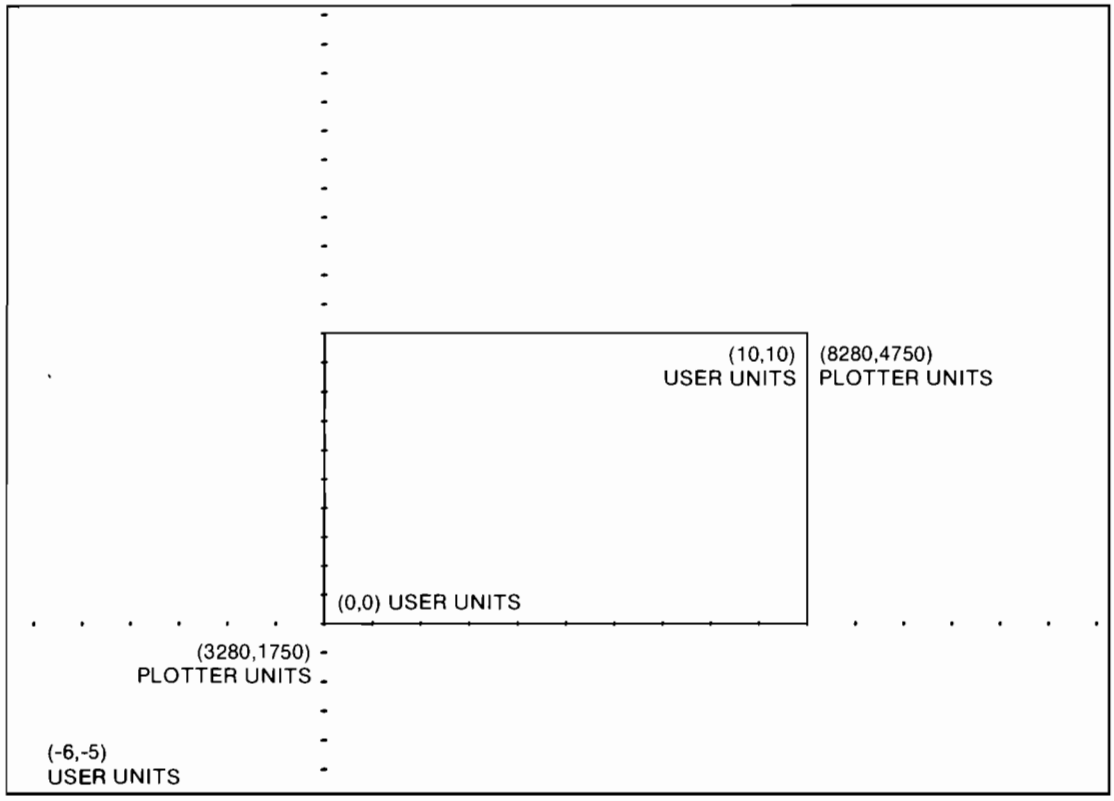
NOTE

The plotter unit is set equal to 0.025 mm for software compatibility with other HP plotters. Internal scaling automatically converts the specified number of plotter units into 0.032 mm physical units, and the pen is moved as close as possible to the specified point in increments of 0.032 mm.

User Units

The size of a user unit is determined by the parameters of the SC command and the setting of the scaling points, LOWER LEFT and UPPER RIGHT . The physical lower left scaling point is assigned the value Xmin, Ymin, while the physical upper right scaling point is assigned the value Xmax, Ymax. (See the SC instruction, Chapter 4). The larger the range of parameters in an SC command and the closer together the scaling points, the smaller the size of a user unit. The total plotting area (including not only the platen area, but also "nearby" and "far-away" areas described under the PA command in Chapter 5) is scaled into units of this size. Thus, if LOWER LEFT is not 0,0 plotter units, and/or UPPER RIGHT is not 11420,8140 it is possible to physically plot to a point outside the rectangle defined by LOWER LEFT (P1) and UPPER RIGHT (P2).

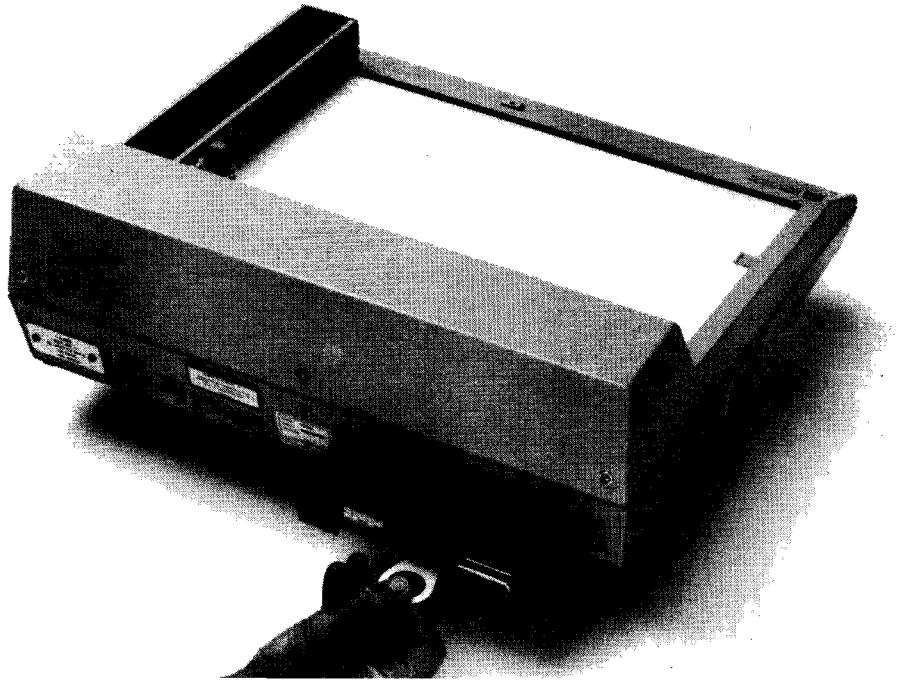
In the following illustration, the scaling points are set to 3280, 1750 and 8280, 4750. Assigning a value to 0,0 to LOWER LEFT and 10,10 to UPPER RIGHT the platen is divided into user units as shown below. The minimum value that can be plotted on the platen surface is -6,-5 . Notice that a user unit is not necessarily the same size on the X axis as it is on the Y axis.



Replacing the Personality Module

Turn the computer and plotter power off, then disconnect the interface cable from the plotter. Loosen the two retaining screws, then using the removal ring, carefully withdraw the personality module from the chassis.

With the ring on the bottom, slide the new personality module into the chassis. Take care to align the circuit board with the grooves in the chassis. Tighten the retaining screws and install the interface cable. Perform a confidence test to ensure that the plotter is operating properly.



7225-A-183-1

Running the Confidence Test

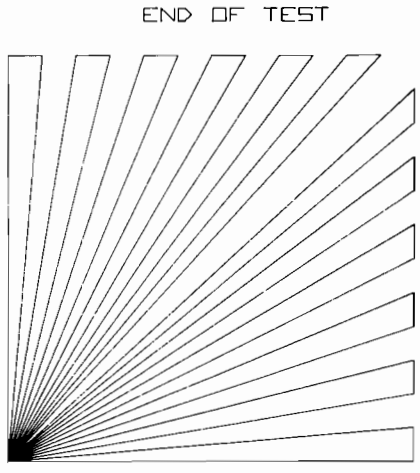
The confidence test performs a tesf of the mechanical and electronic functions of the 7225 plotter and the 17601A personality module and draws the confidence test plot shown below. The confidence test can be performed with the personality module installed or removed. If the module is installed and functioning properly, the fan pattern and the words END OF TEST are drawn. If the module is removed or is malfunctioning, only the fan pattern is drawn.

If the fan pattern is incorrect only when the personality module is installed, the module is malfunctioning. If, after the module is removed, the fan pattern is still incorrect, the malfunction is in the plotter.

The confidence test is performed in this way:

a. Set the line switch on (I ⏚). The plotter performs a power-up initialization sequence. If the personality module is not installed, the ERROR and OUT OF LIMIT lamps will be on steady.

b. Press the CONFIDENCE TEST pushbutton on the rear panel. The CHART LOAD, ENTER, ERROR, and OUT OF LIMIT lamps light momentarily (if the personality module is installed); the pen moves to the upper right mechanical limits; then, the confidence test plot, shown below, is drawn. If the personality module is not installed, the ERROR and OUT OF LIMIT lamps stay on steady and the words END OF TEST are not drawn.



Confidence Test Plot

Operator Maintenance

Maintenance of the plotter is limited to a periodic cleaning of the external surfaces, electrostatic paper hold-down surface, and air filter. Cleaning intervals are determined by the type of operation, local air contamination, and climatic conditions.

WARNING

Disconnect the plotter from the power source prior to performing any maintenance. When cleaning, apply water using a lint-free tissue. DO NOT allow water to run onto electrical components and circuits or through openings in the enclosure as it may create a shock hazard.

Scratches or punctures in the electrostatic paper hold-down surface may expose high voltage conductors. Plotters damaged in this manner should not be operated.

General Cleaning

Clean the outer surfaces as follows:

a. Blow away dust accumulation, using compressed air if available.

b. Clean the outer surface of the instrument with a damp sponge or cloth. Use a mild soap and water solution if necessary. Wipe dry after cleaning.

Electrostatic Paper Hold-down Surface Cleaning

Dust and other contaminants will lower the paper holding capability. Although pen ink will not affect hold-down performance, it may be desirable to remove ink stains as well.

Cleaning moderate contamination can be accomplished as follows:

a. Prepare a mixture of 50% isopropyl alcohol and 50% water by volume.

b. Apply the alcohol/water mixture to the surface using a lint-free tissue. Immediately wipe any moisture from the surface. Never let any liquid stand on surface as it may become permanently damaged.

If the surface cannot be easily cleaned with the alcohol/water mixture, cleaning can be accomplished as follows:

a. Select a clean, lint-free cloth that will not scratch the surface.

b. Remove transparency ink with solvent (HP 5060-6828) and dry thoroughly before continuing the cleaning process.

c. Dampen the cloth with warm water or alcohol and apply a light amount of cleanser such as Ajax® or Comet®.

d. Wipe the surface until it is clean, then rinse the cloth and wipe any remaining cleanser from the surface. Immediately wipe any moisture from the surface.

Air Filter Cleaning

The air filter should be cleaned approximately every three months or when dirt becomes visible on the filter surface, whichever happens first. Remove the filter and either hold it under running water, or wash it in warm, soapy water, followed by a rinse in clean water. Dry the filter thoroughly before replacing it.

Shipment

When the plotter is to be shipped, it is essential that the original packing materials and carton be used. If not available, packing materials and a carton may be ordered through your local Hewlett-Packard sales and service office, or your authorized HP-85 dealer.

If the plotter is being returned to Hewlett-Packard for any reason, contact your local HP sales and service office or dealer. HP service personnel or your dealer will provide shipping instructions, or handle the shipping for you. Attach a tag to the instrument including the following information:

1. Your company name
2. Address
3. Telephone number
4. Name of person to contact
5. Description of problem and desired service
6. 7225 Serial Number.

Do not include the power cord or other operating accessories if returning the instrument to HP.

CAUTION

Failure to use proper packing materials may allow pen arm movement during shipment resulting in possible damage or arm misalignment.

Chapter 2
Plotter/Computer Communications

This chapter describes how your computer communicates with the HP 7225 plotter. Included are addressing the 7225, the function of listen-only mode, bus commands, addressing the 7225 as a talker or listener, and a discussion of sending and receiving data using a variety of computers.

For those of you who want more information on the HP-IB structure and its implementation on the 7225 plotter, additional information can be found in Appendix A of this manual. Those of you who already have an HP-IB interface cable on your computer will find all the information you need in this chapter.

Connecting the Plotter to Your Computer

Connect the HP-IB interface cable to your computer and to the 24 pin HP-IB connector on the rear panel of the plotter.

NOTE

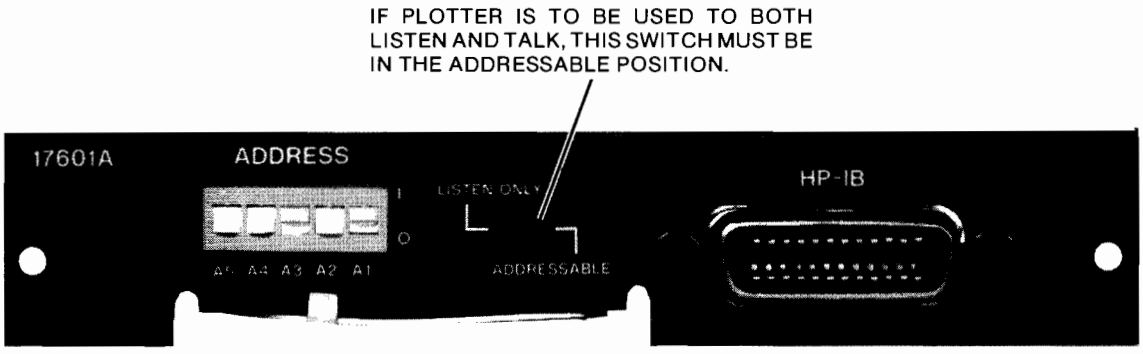
Throughout this manual, the term computer is used to denote a computer, controller, or calculator with an HP-IB interface.

The Plotter Address Code

Since each HP-IB interface can have as many as 15 devices connected to it, each device must be set to a specific address code.

The plotter can be set to one of 30 HP-IB addresses ranging from 0 thru 31. Do not use addresses 21 or 31 which are reserved addresses for HP desktop computers and the universal unlisten command. 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.



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

Address Switch Positions

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
?	_	1	1	1	1	1	31	37

Address Restricted to These Codes When Using Parallel Poll Capability

Reserved For HP Desktop Computer Address

Reserved For Universal Unlisten Command

Listen-Only Mode

The HP 7225 graphics plotter is capable of operating in listen-only mode. The plotter is set to listen-only mode by setting the listen-only switch on the rear of the plotter to the left, the listen-only position. When in listen-only mode, the plotter can only receive data. It cannot talk. Therefore, output instructions should not be used. While output instructions will not work, they will not turn on the error light. The controller may then fail to respond to further commands. No digitizing can be done while in listen-only mode. No responses to a serial poll are possible. However, positive responses to a parallel poll can occur.

Listen-only mode is included to make bare plotting as simple as possible. In this mode it is possible to plot large quantities of data directly from a storage device if the data has been stored with the necessary plot commands. It is also possible to plot directly from an intelligent measuring device (i.e., one that can send the alphabetic plot instructions with the data).

In order to operate the plotter with a computer using an HP plotter ROM, the listen only switch must be in the addressable position. Even when no ROM is being used, the plotter must be set to an addressable mode, if any output is to be sent by the plotter.

Bus Commands

Reaction To Bus Commands DCL, SDC and IFC

The computer can set all devices on the HP-IB system to a predefined or initialized state by sending device clear command DCL. The computer can also set selected devices to a predefined or initialized state by sending selected device clear comand 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. The interface clear command IFC is used by the computer to override all bus operations and return the bus to a known quiescent state.

Upon receipt of either DCL, SDC or IFC commands, the 7225 plotter completes any vector currently in process and stops, resets the parser (instruction decoder) to expect a new instruction, and disables any current output (talk).

The device clear and interface clear commands **do not** reset the plotter to its default or power-on conditions.

Serial and Parallel Polling

Polling is the process used by the computer to determine which device on the HP-IB bus has initiated a require service message. The conditions which will cause the require service message to be sent to the computer are defined by the Input Mask Instruction, IM. Refer to Chapter 3.

The plotter will respond to a serial poll by sending the status byte as described under the Output Status Instruction, OS (refer to Chapter 3). This status byte will indicate that the plotter has or has not sent a require service message.

The plotter will respond to a parallel poll only if it has sent a require service message. The response to a parallel poll is limited to setting the appropriate data line to a logical 1. The data line is determined by the plotter address value.

The Serial Poll

The serial poll is so named because the computer polls devices on the bus one at a time, rather than all at once. When polled by the computer, the plotter transmits the status byte. If bit position six of the status byte is a "zero", the plotter has not requested service. If it is a "one", the plotter has requested service. The S-mask parameter of the Input Mask instruction IM is used to specify which status byte conditions will send the require service message.

NOTE

Bit six of the status byte can only be read by a serial poll. The interface line SRQ will remain set to a logical 1 until the condition which initially caused the service request message is corrected. Positive responses to serial polls will continue until the condition causing the SRQ line to be set is corrected. When the status byte is read by an OS command, bit six is always zero.

During a serial poll, the plotter must be instructed to talk and the computer to listen. Therefore, a serial poll cannot be executed when the plotter is in the listen-only mode.

The Parallel Poll

The plotter responds to a parallel poll by sending a logical 1 on one of the eight data lines. The line used is determined by the 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**	Plotter Preset Address
6	1	2	
7	0	1	

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

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

The P-mask parameter of the Input Mask instruction IM is used to specify which status byte conditions will result in a logical 1 response to a parallel poll. (See IM, Chapter 3).

Addressing the 7225 As a Talker or Listener

Communication with the 7225 Plotter is completely dependent on understanding the addressing protocol of your computer. Therefore, you may wish to review this aspect of your computer before proceeding.

Low Level Computers

On low level computers, addressing devices on the HP-IB bus is accomplished using mnemonics, such as CMD, which serve as the "bus command."

When bus commands are necessary, a typical 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 listener along with other addressed listeners.

This basic addressing sequence simply states who is to talk to whom. The unlisten command ("?") plays a vital role 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.

Intelligent Computers

In more intelligent computers, higher level input/output (I/O) statements are used to specify device addresses on the HP-IB bus. In these cases, the addressing protocol (unlisten, talk, listen) is a function of the computer's internal operating system and need not be of concern to the user.

Sending And Receiving Data

Computer-To-Plotter

Transmitting data from a computer to the plotter is typically accomplished using I/O statements such as WRITE, PRINT, PRINT@, PRINT#, or OUTPUT. The following examples of sending program data to the plotter from various computers are only intended to illustrate the necessity for understanding the I/O statement protocol implemented by your computer. Each of these examples will cause the plotter to label the identity of the computer sending data, beginning at the X,Y coordinates 1000,2000. The examples involve sending both character string and numeric data as variables, and constants or literals.

HP 9825 Example

```
0: fxd 0;dim A$[13]
1: '' SENDING DATA''→A$
2: 2000→Y
3: 9825→B
4: wrt 705,''pa1000,'',Y
5: wtb 705,''1bHP'',str(B),A$,3
6: end
```

A terminator is sent by the 9825 at the end of a wrt statement.

Result: HP 9825 SENDING DATA

HP 9835/9845 Example

```
10   PRINTER IS 7,5
20   A$='' SENDING DATA''
30   B=9835
40   C=9845
50   Y=2000
60   PRINT ''PA1000,'';Y
70   PRINT USING ''K'';''LBHP '',B,''/'',C,A$,CHR$(3)
80   END
```

A terminator is sent by the 9835/9845 at the end of a PRINT statement.

Result: HP 9835/9845 SENDING DATA

HP 2647 Example

```
10 ASSIGN ''H#5'' TO #1
20 DIM A$(13)
30 A$=''SENDING DATA''
40 Y=2000
50 B=2647
60 PRINT #1;''PA1000,'';Y
70 PRINT #1;''LBHP'';B;A$;CHR$(3);
80 END
```

A terminator is sent by the 2647 at the end of PRINT #1 statements.

Result: HP 2647 SENDING DATA

HP-85 Example

```
10 PRINTER IS 705
20 A$=''SENDING DATA''
30 B=85
40 Y=2000
50 PRINT ''PA1000,'',Y
60 PRINT ''LBHP'';B;A$;''N''
70 END
```

A terminator is sent by the HP-85 following PRINT statements.

Result: HP 85 SENDING DATA

TEK 4051 Example

```
100 DIM A$[13],B$[1]
110 A$='' SENDING DATA''
120 Y=2000
130 B=4051
135 B$=CHR$(3)
140 PRINT @5:''PA1000,'';Y;'';''
150 PRINT @5:''LBTEK '';B;A$;B$
160 END
```

No terminator is sent by the TEK 4051. It must, therefore, be included in each PRINT @ 5 statement.

Result: TEK 4051 SENDING DATA

Commodore PET 2001 Example

```
10 OPEN 5,5
20 DIM A$(13)
30 A$=" SENDING DATA"
40 B=2001
50 Y=2000
60 PRINT#5,"PA1000 ,";STR$(Y)
70 PRINT#5,"LBPET ";B;A$;CHR$(3)
80 END
```

A terminator is sent by PET at the end of the PRINT#5 statement.

Result: PET 2001 SENDING DATA

Plotter-To-Computer

Outputting data from the plotter to the computer is typically accomplished using I/O statements such as READ, INPUT, INPUT@, INPUT#, or ENTER. The following examples of obtaining output data from the plotter using various computers are only intended to illustrate the necessity for understanding the I/O statement protocol implemented on your computer. Each of these examples commands the pen to move to plotter coordinates X=1000, Y=1000 and then output the current pen position and the plotter identifier string to the computer. The identifier string returned is 7225A for both 7225A and 7225B plotters.

HP 9825 Example

```
0: dim A$[5];fxd 0
1: wrt 705,"pa1000,1000;oc"
2: red 705,A,B,C
3: wrt 705,"OI"
4: red 705,A$
5: dsp A,B,C,A$
6: end
```

Displayed current pen position and identification.
1000 1000 0 7225A

HP 9835/9845 Example

```
10   PRINTER IS 7,5
20   PRINT ''PA1000,1000;OC''
30   ENTER 705;A,B,C
40   PRINT ''OI''
50   ENTER 705;A$
60   DISP A,B,C,A$
70   END
```

Displayed current pen position and identification.

1000 1000 0 7225A

HP 2647 Example

```
10 ASSIGN ''H#5'' TO #1
20 PRINT #1;''PA1000,1000;OC;''
30 READ #1;A,B,C
40 PRINT #1;''OI''
50 READ #1;A$.
60 PRINT A,B,C,A$
70 END
```

Displayed current pen position and identification.

1000 1000 0 7225A

HP-85 Example

```
10 PRINTER IS 705
20 PRINT ''PA1000,1000;OC''
30 ENTER 705;A,B,C
40 PRINT ''OI''
50 ENTER 705;A$
60 DISP A,B,C,A$
70 END
```

Displayed current pen position and identification.

1000 1000

0 7225A

TEK 4051 Example

```
100 DIM A$(5)
110 PRINT @ 5:''PA1000,1000;OC;''
120 INPUT @ 5:A,B,C
130 PRINT @ 5:''OI;''
140 INPUT @ 5:A$
150 PRINT A,B,C,A$
160 END
```

Displayed current pen position and identification.

1000	1000	0	7225A

Commodore PET 2001 Example

```
10 OPEN 5,5
20 PRINT#5,''PA1000,1000;OC;''
30 INPUT#5,A,B,C
40 PRINT#5,''OI''
50 INPUT#5,A$
60 PRINT A,B,C,A$
70 END
```

Displayed current pen position and identification.

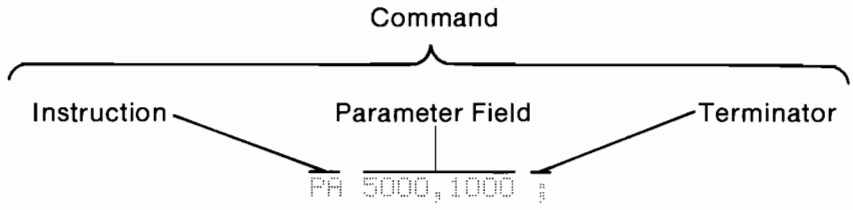
1000	1000	0	7225A

Chapter 3
General Programming Instructions

This chapter introduces the 7225 plotter instruction set and defines parameter ranges and the instruction syntax that is used throughout the manual. General instructions that establish default and initial parameters and the conditions under which an error can occur are also defined. Instructions that allow the user to output status, output identification, and output options from the plotter are also explained.

The 7225 Plotter Instruction Set

The instruction set for the 7225 plotter consists of 39 Hewlett-Packard Graphics Language (HP-GL) instructions which are categorized 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 -32767 and +32767. No decimal is allowed. If no sign is specified, the parameter is assumed to be positive.

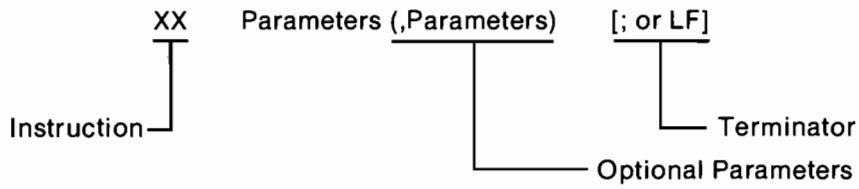
2. Decimal Format: Numbers between ±127.999 with an optional decimal point. Fractional inputs between -0.004 and +0.004 are interpreted as zero. If no sign is specified, the parameter is assumed to be positive.

3. Label Fields: Any combination of text, numeric expressions, or string variables. Refer to the label instruction LB (Chapter 6) 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 semicolon or line feed. Some computers automatically send the terminator at the end of the parameter field. The syntax used throughout this manual is [; or LF].

The label instruction LB terminator must be an ASCII ETX (binary 3).

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:

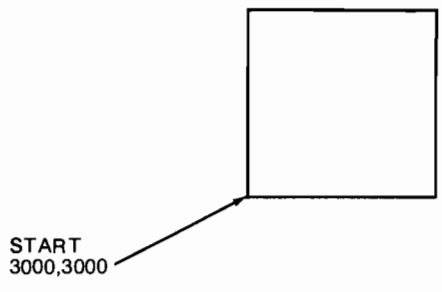


NOTE

The parentheses used to show optional parameters are not used when writing programs. The optional parameters are separated (delimited) using only the comma.

Consider the following example of some typical instructions, parameter fields, and terminators.

```
LINE 1   PU;PA3000,3000;PD;
LINE 2   PR0,1000,1000,0,0,-1000,-1000,0;PU;
```



Line 1 raises the pen, causes the plotter to move to the absolute position X=3000, Y=3000, and then lowers the pen.

Line 2 moves the pen relative (PR) to the position commanded in line 1 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. One plotter unit is equal to 0.025 mm. The pen is then raised.

Note the use of the terminator [;] between commands in line 2. The terminator [;] shown at the end of each program line is not necessary if your computer automatically generates a line feed [LF] following the last entry after the I/O command statement.

The examples shown in this manual do not include addressing protocol or I/O command statements. Therefore, it will be necessary for the user to add the appropriate addressing protocol and I/O command statements implemented by the computer being used. Refer to Chapter 2, Sending and Receiving Data, for examples of addressing protocol and I/O command statements implemented by a variety of computers.

NOTE

BASIC (Beginners All-purpose Symbolic Instruction Code) statements are included in examples as necessary to key the user to one possible solution to performing the example. However, PRINT commands and formatting necessary to actually send HP-GL instructions to the plotter are not included.

Some variable names used in examples may need to be altered to conform with the variable name restrictions of your computer.

The instruction set for the 7225 plotter is summarized in the following table.

Plotter Instruction Set

Instruction		Definition
VECTOR GROUP		
PA	x,y(,x,y(,...))	Plot absolute
PD		Pen down
PR	x,y(,x,y(,...))	Plot relative
PU		Pen up
CHARACTER GROUP		
CA	n	Designate alternate set n
CP	spaces, lines	Character plot
CS	m	Designate standard set m
DI	run, rise	Absolute direction
DR	run, rise	Relative direction
LB	c....c	Label ASCII string
SA		Select alternate character set
SI	width, height	Absolute character size
SL	tan θ	Absolute character slant (from vertical)
SR	width, height	Relative character size
SS		Select standard character set
UC	x,y,pen(,...)	User defined character
LINE TYPE GROUP		
LT	t(,l)	Designate line type and length
SM	c(,n)	Symbol mode c at n^{th} coordinate
VS	v	Select velocity v
DIGITIZE GROUP		
DC		Digitize clear
DP		Digitize point
OC		Output commanded position & pen status
OD		Output digitized point & pen status
AXES GROUP		
TL	tp(,tn)	Tick length
XT		X-axis tick
YT		Y-axis tick
SET-UP GROUP		
IP	p1x,p1y,p2x,p2y	Input p1 and p2
IW	xlo,ylo,xhi,yhi	Input window
OP		Output p1 and p2
SC	Xmin,Xmax,Ymin,Ymax	Scale
CONFIGURATION AND STATUS GROUP		
DF		Set default values
IM	e(,s(,p))	Input e,s, and p masks
IN		Initialize
OA		Output actual position and pen status
OE		Output error
OF		Output factors
OI		Output identification
OO		Output options
OS		Output status

The Default Instruction DF

The default instruction DF sets 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	Mechanical limits of plotter
Relative character size	Width = 0.75% of $\lvert P2_X - P1_X \rvert$ Height = 1.5% of $\lvert P2_Y - P1_Y \rvert$
Symbol mode	off
Tick length	tp = tn = 0.5% of $\lvert P2_X - P1_X \rvert$ for Y tick and 0.5% of $\lvert P2_Y - P1_Y \rvert$ for X tick
Standard character set	Set 0
Alternate character set	Set 0
Character slant	0°
Mask value	223,0,0
Digitize clear	on
Scale	off
Pen velocity	25 cm/s

The current pen location is not changed. P1 and P2 are not changed.

The Initialize Instruction IN

The initialize instruction IN returns the plotter to the initial power-on state under 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. 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 upper right corner of the platen.

The scaling points P1 and P2 are set to the points P1 = (328,279) and P2 = 10328,7479).

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

The Input Mask Instruction IM

The input mask instruction IM specifies 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 status byte and turn on the error light on the 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	Not used
16	5	Unknown character set
32	6	Position overflow
64	7	Not used
128	8	Not used

For example, an E-mask value 60 (4 + 8 + 16 + 32) will specify that error numbers 3 thru 6 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. Error numbers 4, 7, and 8 are always zero.

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 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)
128	7	Chart load on

Only combinations of the status bits 0-5 and bit 7 can be specified to send the require service message. Bit 6 is used to specify whether or not the plotter has sent the required service message.

For example, an S-mask value of 16 specifies that the " Ready for data" bit (bit 4) of the status byte will send the required service message. The other 6 bits (bits 0 through 3, bit 5 and bit 7) will not send the required 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
64	6	Require service sent (SRQ)
128	7	Chart load on

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 set to default values 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 required 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 Output Error Instruction OE

The output error instruction OE makes the decimal equivalent of the last 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.

This instruction should not be used in listen-only mode. When an OE command is received, the plotter converts the last error to 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	Not used
5	Unknown character set
6	Position overflow
7	Not used
8	Not used

After the error code is output to the computer, 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 makes 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.

This instruction should not be used in listen-only mode.

Upon receipt of the OS command, the internal eight-bit status byte is converted to an ASCII decimal integer between 0 and 255. The decimal integer is output 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; cleared by reading OP output
4	2	Digitized point available; cleared by reading digitized value
8	3	Initialized; cleared by reading OS output
16	4	Ready for data
32	5	Error; cleared by reading OE output
64	6	Require service message set (always 0 for OS, 0,1 for serial poll)
128	7	Chart load on

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

The Output Identification Instruction OI

The output identification instruction OI commands the plotter to make an identifier ready for output.

Syntax:

OI [; or LF]

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

This instruction should not be used in listen-only mode.

After an OI command is received, the 7225 plotter will always output the following character string:

7225A CR LF

The Output Options Instruction OO

The output options instruction OO commands the plotter to make the decimal equivalent of eight option parameters available for output.

Syntax:

OO [; or LF]

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

This instruction should not be used in listen-only mode.

The 7225 will always respond to this instruction with the same message consisting of eight ASCII integers:

0,0,0,0,0,0,0,0 CR LF

indicating none of the options covered by this instruction apply to the 7225 plotter.

Chapter 4
Scaling

This chapter describes the instructions that enable you to scale the plot into user units. Included in this chapter are the following instructions:

Input P1 and P2 (IP)

Output P1 and P2 (OP)

Output Factors (OF)

Scale (SC).

A discussion of scaling without using the SC command is contained in Appendix B.

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, and also within platen maximum range. $0 \leqslant X \leqslant 11420$ and $0 \leqslant Y \leqslant 8140$.

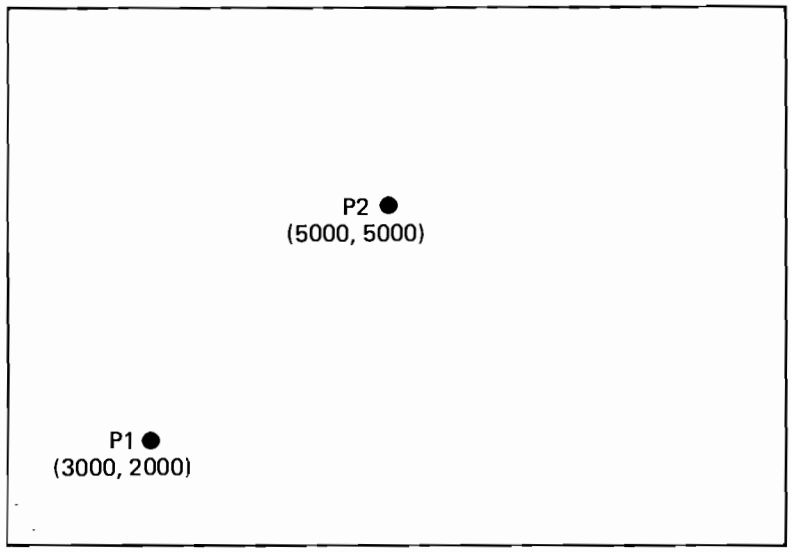
Upon receipt of a valid IP command, bit position 1 of the output status word is set true (1). A command IP with no parameters (IP;) will default to the values P1 = 328, 279 and P2 = 10328, 7479.

Upon initialization, the 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 relocates the scaling points P1 and P2 to the positions shown on the figure.

LINE 1. IP3000,2000,5000,5000;

$P1_X$ $P1_Y$ $P2_X$ $P2_Y$



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

An anomaly exists in the plotter. When P1 as set by an IP command is moved to using [LOWER LEFT], a displacement of as much as 8 mm (325 plotter units) in X can occur between the actual and programmed position of the pen. Referring to the table below, if $A <= P1_X < B$ the pen will move to the coordinates $A, P1_Y$ when [LOWER LEFT] is pressed. Internally, the plotter recognizes the programmed position. An OP command returns the same coordinates set by the IP command. Subsequent plots are scaled correctly according to the programmed location of P1 and P2. Only when [LOWER LEFT] is pressed does P1 appear to be at the incorrect X coordinate.

n	A	B
$0 \leqslant n < 5$	$325n$	$325(n + 1)$
$5 \leqslant n < 13$	$325n + 1$	$325(n + 1) + 1$
$13 \leqslant n < 21$	$325n + 2$	$325(n + 1) + 2$
$21 \leqslant n < 30$	$325n + 3$	$325(n + 1) + 3$
$30 \leqslant n < 35$	$325n + 4$	$325(n + 1) + 4$*

*$B \leqslant 11420$

The Output P1 and P2 Instruction OP

The output P1 and P2 instruction OP makes 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. This instruction should not be used in listen-only mode.

When requested, the coordinates will be output as four ASCII integers as follows:

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

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

The Output Factor Instruction OF

The output factor instruction OF makes the number of plotter units per millimetre in each axis available for output.

Syntax:

OF [; or LF]

This instruction uses no parameters, however, the terminator ; or LF must be included to complete the instruction.This instruction should not be used in listen-only mode.

The 7225 will always output

40 , 40 CR LF

indicating that there are 40 plotter units per millimetre in the X axis and 40 plotter units per millimetre in the Y axis (0.025 mm/plotter unit) on the 7225 plotter.

The Scale Instruction SC

The scale instruction SC assigns user unit values to the lower left scaling point (usually P1) and the upper right scaling point (usually P2), and thus maps user units onto the whole plotting area.

Syntax:

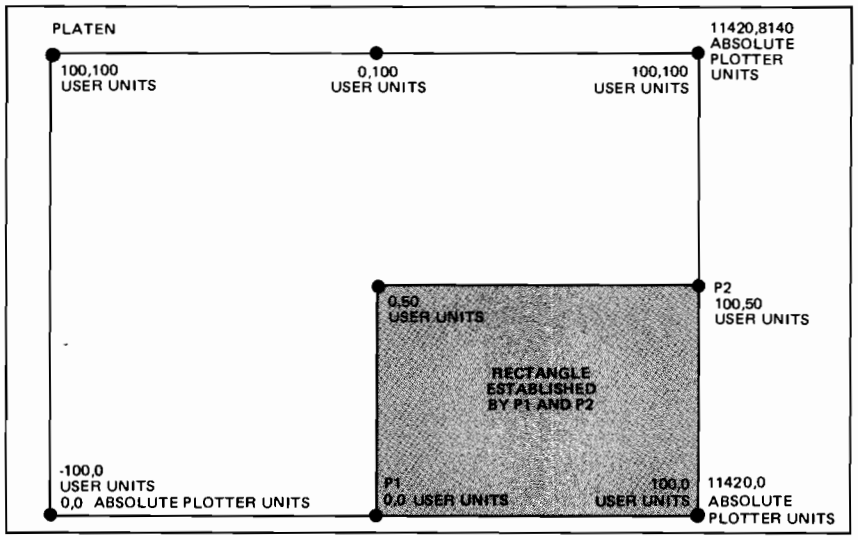
SC Xmin, Xmax, Ymin, Ymax [; or LF]

An SC command with no parameters (SC;) returns the plotter to unscaled mode in which parameters of plot commands are interpreted as absolute plotter units.

When parameters are used, all four parameters are required and must be integers between ±32767. The Xmin, Ymin values are assigned to the lower left scaling point and the Xmax, Ymax values are assigned to the upper right scaling point. Execution of an SC command with valid parameters places the plotter in scaled mode in which parameters of plot commands are interpreted as user units.

The whole plotting area, including the platen area, and the nearby and faraway areas beyond the platen, (see PA, Chapter 5), are scaled into user units. Thus, scaling extends beyond the rectangle established by P1 and P2. The size of a user unit depends on both the range of the scaling parameters and the X or Y distance between P1 and P2. The illustration below shows the absolute plotting area (mechanical limits) which results from the following statements.

LINE 1. `IP5710,0,11420,4070`
LINE 2. `SC0,100,0,50`

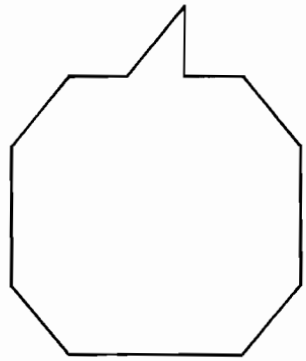


Let us now assume we have scaled an area of the platen into 25 x 16 user units. With integer scaling, plotting is only possible to coordinates with integer values. It is only possible to plot to a finite number of points on the platen, in the current example 26 x 17 (X coordinates 0 to 25, Y coordinates 0 to 16). You cannot draw to the location 2.2,3.7; the line must be drawn to 2,3 or 2,4. When trying to plot functions where the fractional portion of the function's value is significant, truncation or rounding performed to send integer values as parameters of plot commands, produces some unexpected and unsatisfactory results. The following two programs illustrate the problem and its solution.

The first program is an attempt to draw a circle in the center of the plotting area. The constants 12.5 and 8 in lines 3 and 4 center the circle in the plotting area. Since line 5 must be formatted to send integer values, significant fractional parts are lost, and the result is an undiscernable plot. The scaling 0 to 25, and 0 to 16 does not allow plotting to enough points, and results in a circle of poor resolution.

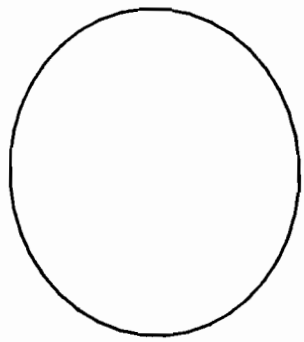
Send:

```
 LINE 1. IN;SCO,25,0,16;
 LINE 2. FOR T=0 TO 2*PI STEP PI/20
 LINE 3. X=2.5*COS(T)+12.5
 LINE 4. Y=2.5*SIN(T)+8
*LINE 5. PA X,Y;PD
 LINE 6. NEXT T
 LINE 7. PU;
```



In the second example, a constant of 1000 is used in both the scaling and the values of X and Y. Note the constants that center the circle have changed to correspond with the SC command (lines 3 and 4). The use of the multiplier 1000 solves the resolution problem.

```
 LINE 1. IN;SCO,25000,0,16000;
 LINE 2. FOR T=0 TO 2*PI STEP PI/20
 LINE 3. X=2.5*1000*COS(T) +12500
 LINE 4. Y=2.5*1000*SIN(T)+8000
*LINE 5. PA X,Y;PD;
 LINE 6. NEXT T
 LINE 7. PU;
```

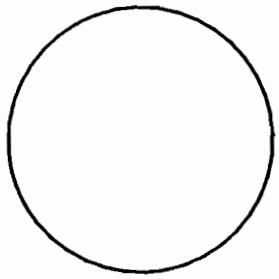


Notice that the plot is not a perfect circle. This is a result of the aspect ratio of the plotter ($|P1_X - P2_X| \neq |P1_Y - P2_Y|$) and the parameters of the SC command. In the preceeding example, which has been slightly reduced, P1 and P2 were the default values.

There are two ways to compensate for this distortion. The first is to define P1 and P2 so that the plotting area is square and scale the area alike in X and Y.

Send:

```
LINE 1.  IN;IP 1000,1000,8000,8000;
LINE 2.  SC 0,2 5000,0,25000;
LINE 3.  FOR T=0 TO 2*PI STEP PI/20
LINE 4.  X=2.5*1000*COS(T)+12500
LINE 5.  Y=2.5*1000*SIN(T)+12500
*LINE 6.  PA X,Y;PD;
LINE 7.  NEXT T
```

We now plot a perfect circle

The second method of solution is to use any scaling points, but compensate for the aspect ratio either in the scaling instruction, or the calculation of the X and Y variables.

Program 1

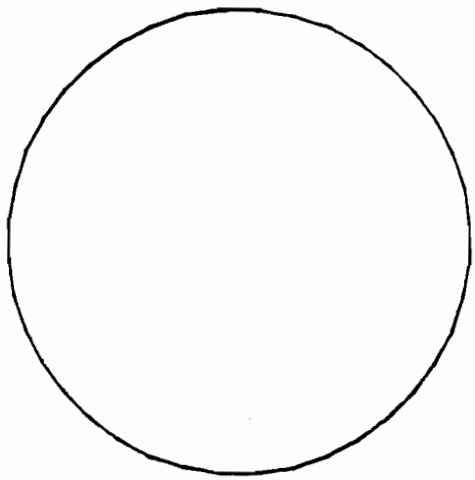
Send:

```
LINE 1. IN;IP328,279,10328,7479;
LINE 2. SCO,1000,0,720;
LINE 3. FOR T=0 TO 2*PI STEP PI/20
LINE 4. X=2.5*50*COS(T)+500
LINE 5. Y=2.5*50*SIN(T) +360
*LINE 6. PA X,Y;PD;
LINE 7. NEXT T
LINE 8. PU;
```

Line 1 sets P1 and P2 to default values.
Line 2 sets 1 scaled unit = 10 plotter units.

Offsets 500 and 360 in lines 4 and 5 center circle in plotting area.

If the scale command sets an equal number of user units in the X and Y axis, the X or Y value must be adjusted to correspond with the aspect ratio when the plotting area is not square. Both programs plot the same circle.



Program 2

Send:

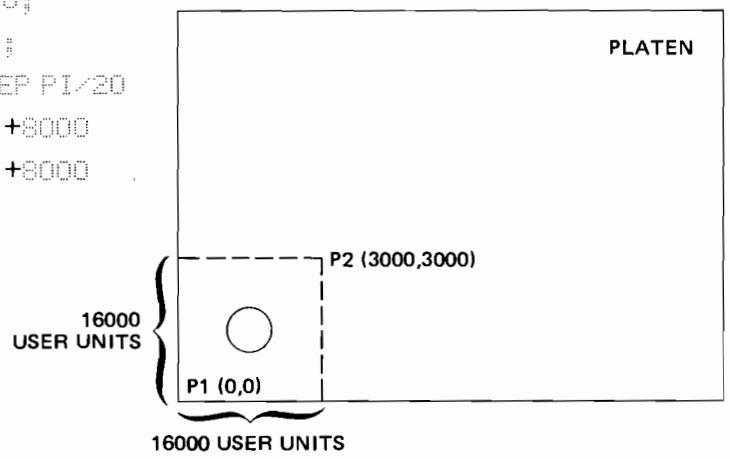
```
LINE 1. IN;IP328,279,10328,7479;
LINE 2. SCO,1000,0,1000;
LINE 3. FOR T=0 TO 2*PI STEP PI/20
LINE 4. X=2.5*50*COS(T)+500
LINE 5. Y=2.5*69.44444444*SIN(T)+500
*LINE 6. PA X,Y;PD;
LINE 7. NEXT T
LINE 8. PU;
```

Line 1 sets default P1 and P2 so $|P1_X - P2_X| = 10000$ and $|P1_Y - P2_Y| = 7200$

7200/10000=50/69.44444

Changing P1 and P2 with an IP command can move the plot to a different area of the platen and can change the plot size. If geometrically accurate plots are desired, it is always necessary to adjust for a new P1 and P2 by changing the scale (SC) command, or by scaling the X and Y values with a multiplier. The following listing plots a small circle in the lower-left-hand corner of the platen.

```
LINE 1. IN;IP0,0,3000,3000;
LINE 2. SCO,16000,0,16000;
LINE 3. FOR T=0 TO 2*PI STEP PI/20
LINE 4. X=2.5*1000*COS(T)+8000
LINE 5. Y=2.5*1000*SIN(T)+8000
*LINE 6. PA X,Y;PD;
LINE 7. NEXT T
LINE 8. PU;
```



There are two other implementations of scaling which may be of interest to the user. One involves the use of an HP Graphics ROM, or a software support package, (computer dependent and available from your HP sales representative, or your authorized HP-85 dealer). Scaling with these plotting aids is accomplished with a scaling mnemonic, and aspect ratios and non-integers are handled automatically.

The second is use of algebraic formulas to convert from user to plotter units. Some users may wish to do this to compute desired window parameters without using output commands, or to cope with non-integer data where it is difficult to figure a convenient multiplier. This method of scaling is covered in Appendix B of this manual.

Chapter 5
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 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.

Examples which use the PD and PU instructions are included under the PA and PR instructions.

The Plot Absolute Instruction PA

The plot absolute instruction PA moves the pen to the point specified, in plotter or user units, by the X and Y-coordinate parameters that complete the command. See the Scale Instruction (Chapter 4) for user unit considerations.

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 pairs) and be integers. The X-coordinate parameter specifies the absolute X location to which the pen will move in either plotter units, or user units. The Y coordinate parameter specifies the absolute Y location to which the pen will move in either plotter units, or user units. If scaling is on, both coordinates are in user units. If scaling is off, both coordinates are in plotter units.

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

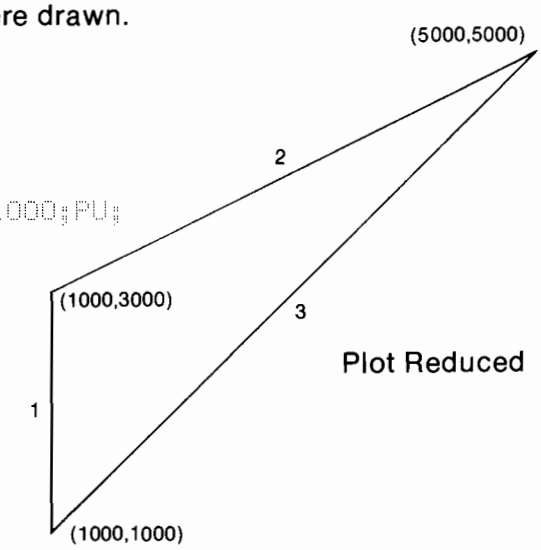
Using the PU or PD instructions, a pen control command can be placed before or after the PA command, raising (PU), or lowering (PD) the pen. If no pen control command is specified, the pen will assume the pen state (pen up or pen down) of the previous statement.

Plotting is done only within the currently defined "window" area on the platen. Refer to the Input Window Instruction IW, Chapter 7, for further information.

The following example causes the plotter to draw a triangle. The plotted lines have been numbered in the order in which they were drawn.

Send:

```
LINE 1: PA 1000,1000;PD;
LINE 2: PA 1000,3000,5000,5000,1000,1000;PU;
```

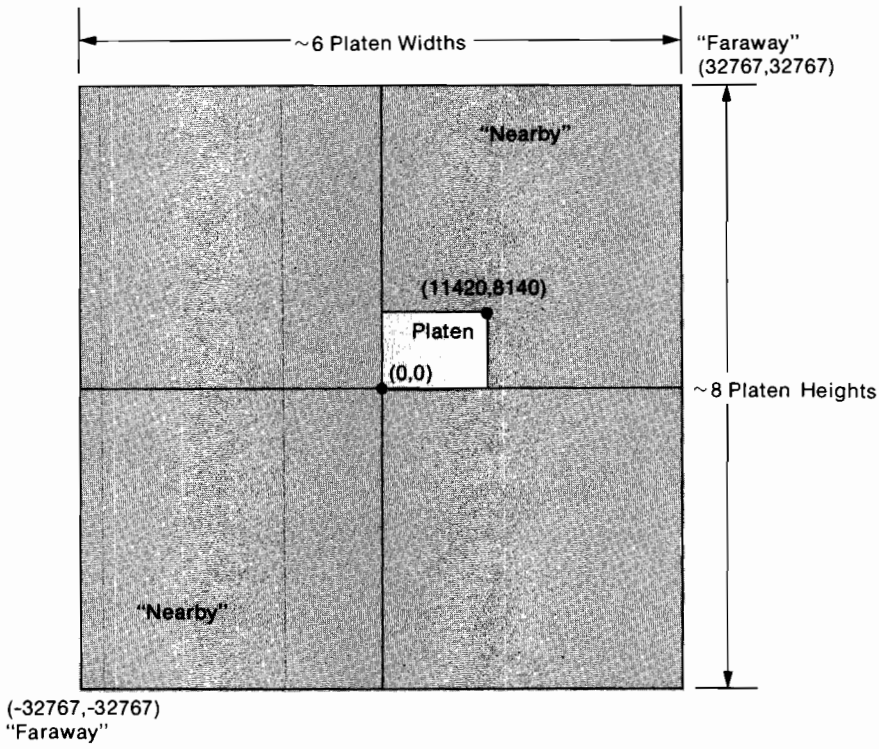


Plot Reduced

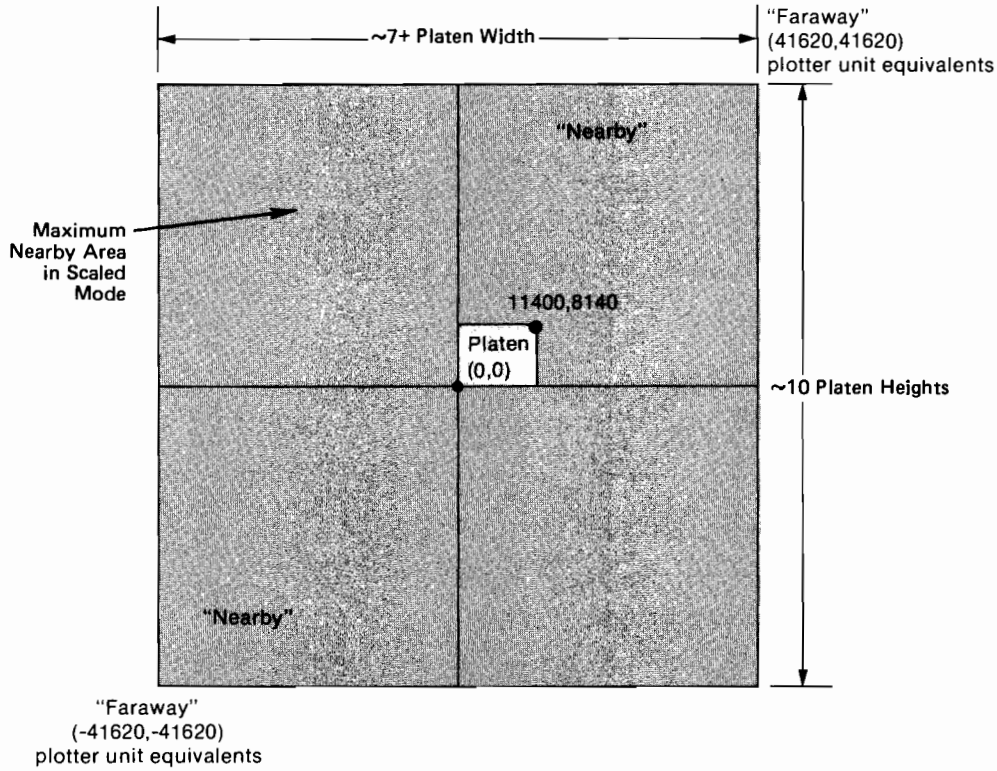
If the point specified by a PA command lies off the platen surface, but within the "nearby" area, a line is drawn to the platen limit and then the pen is raised and the OUT OF LIMIT light will turn on steady. The pen remains raised until a point on the platen is specified.

If the point lies off the platen and in the "faraway" area, the pen is raised, the OUT OF LIMIT light will blink, but the pen will not move from its present position in the plotting area. The pen remains raised until it moves from a point inside the platen area, which was reached either using a valid PA command, or using front panel controls.

"Nearby" and "faraway" areas when scaling is off are shown below. The numbers are plotter units. The platen area is lightly shaded. The "nearby" area is darker and the faraway area is the white area beyond the shading.



When scaling is on, nearby and faraway areas change considerably as can be seen in the following diagram. When scaling is on, a point is 'faraway" if any parameter is more negative than -32767, or greater than +32767, or if its plotter unit equivalent is not in the approximate range ±41620. The plotter units equivalent = (parameter in user units) x (no. of plotter units per user unit).



This diagram represents the maximum "nearby" area when scaling is on and, in the above diagram, you are limited by the plotter unit equivalents being beyond the acceptable range. Consider, however, the case where P2 is set to some point in the center of the platen area. Now if scaling is set at 0 to 32000 on both X and Y axes, you will be in the "faraway" area if you plot the point 42000,42000, yet that would lie within the platen area. Plotter unit equivalents are in the acceptable range, but the actual parameters are not.

"Faraway" is that area in which the plotter is in its lost state. Another way of describing it is to say the coordinates are out-of-range. Coordinates within the platen area and "nearby area" are in-range. When scaling is off, in-range coordinates are defined as both X and Y parameters being integer plotting units having values between -32767 and +32767. When scaling is on, in-range coordinates must have both X and Y parameters between -32767 and +32767 and, when converted to plotter units, must also be in the approximate range -41620 to +41620. When out-of-range parameters are given, the plotter will enter its lost state. The OUT OF LIMIT light will blink. However, the error light will not turn on.

The Plot Relative Instruction PR

The plot relative instruction PR moves the pen relative to its current location by the number of plotter or user units specified by the X and Y parameters that complete the command. See Scale Instruction (Chapter 4) for user unit considerations.

Syntax:

PR X_1 increment, Y_1 increment (,X_2 increment, Y_2,...,...,
X_N increment, Y_N increment) [; or LF]

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

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

Parameters must be integers.

The sign of the increment parameters determines 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, separated by commas, can be listed after the PR instruction. The pen will move relative to the previous point in the order given.

In-range coordinates are defined as:

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

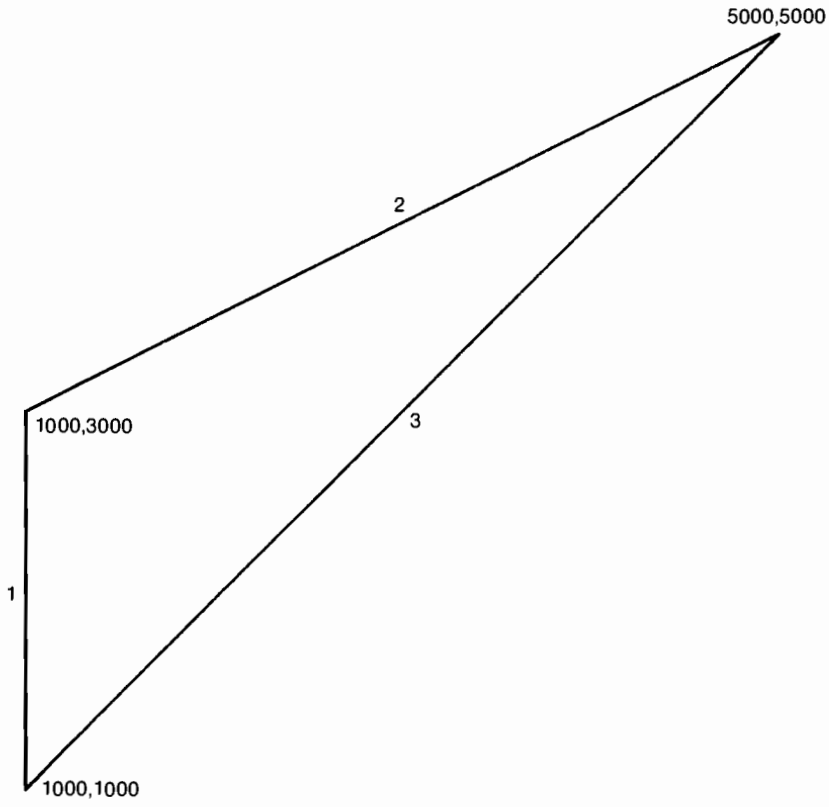
2. each succeeding X and Y increment when added to the current X and Y coordinate, does not exceed ±32767 plotter units when referenced from the point 0,0, when scaling is off, and plotter unit equivalents do not exceed ±41620 when scaling is on.

If a PR command specifies a point off the platen in the "nearby" area as described under the PA instruction, the pen draws a line to the limit of the platen and stops with the pen raised. The OUT OF LIMIT light turns on steady. The plotter recognizes subsequent PR commands while in this area. If a PR command specifies a point in the "faraway" area, the pen is raised and does not move. The OUT OF LIMIT light blinks and the plotter does not recognize subsequent PR commands, until a PA command with valid parameters, or pen movement with front panel controls, moves the pen to the "nearby" area, or within the platen area.

The following example program causes the plotter to draw a triange identical to the one previously drawn using the PA instruction only.

Send:

```
LINE 1.  IN;PA1000,1000;PD;PR0,2000;
LINE 2.  PR4000,2000,-4000,-4000;PU;
```



Plotting With Variables

In many plotting applications it is necessary to plot using variables rather than fixed numbers to define the X and Y coordinate values. The values of all HP-GL statement parameters have the same restrictions (integer or decimals in a valid range) when sent as variables as when sent as literals (fixed numbers). The terminators and delimiters of HP-GL statements must be sent to the plotter too. The method of defining output format and variable precision varies from computer to computer. Refer to your computer manual for the appropriate format statements that may be needed in your program.

The following example illustrates the use of variables in plotting. Quotation marks are used by many computers to define the literal characters that are to be sent. Note the comma in line 6 which is part of the HP-GL statement and must be sent to the plotter. Here it is sent as a literal in quotes. In order for this statement to be acceptable to the plotter, the variables X and Y must be sent as integers. It may be necessary to add a statement to assure this is done by your computer.

```
LINE 1.  IPO,0,7544,7544;
LINE 2.  SCO,10,0,10;
LINE 3.  FOR T=0 TO 2*πSTEPπ/20
LINE 4.  X=1.5*COS(T)+5
LINE 5.  Y=1.5*SIN(T)+3
*LINE 6.  ''PA'',X,'','',Y,'';PD;''
LINE 7.  NEXT T
LINE 8.  PU;
```

This statement causes the plotter to move to the absolute value defined by the X and Y variables and lower the pen. The HP-GL mnemonics, delimiters and terminators are sent as literals in quotes on some computers. They are included here to delineate the variables X and Y.

Chapter 6
Labeling Plots

This chapter describes the instructions that allow you to label the plot with alphanumeric characters and symbols using the plotter's internal character sets. Included are instructions to specify the size, slant, and direction of characters, as well as the positioning of labels.

Plotter Character Sets

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

CHARACTER SET 0

```
! "#$%&' ()*+,-./0123456789:;<=>?@
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 before drawing any of the shaded symbols. Therefore, when an accented letter is required, the letter should be entered first, followed by the accent.

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 designates one of the five character sets (0 thru 4) as the standard character set.

Syntax:

CS 0 thru 4 [; or LF]

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

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

A CS command with invalid parameters will turn on the error light and the character set designated as standard will not change.

The Designate Alternate Character Set Instruction CA

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

Syntax:

CA 0 thru 4 [; of LF]

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

Any of the 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.

A CA command with invalid parameters will turn on the error light and the character set designated as the alternate will not change.

The Select Standard Set Instruction SS

The select standard set instruction SS selects the standard set as the character set to be used for labeling.

Syntax:

SS [; or LF]

No parameters are used, however the terminator ; or LF must be included to complete the command. The SS command with parameters will turn on the error light, but otherwise is ignored.

The standard ASCII character set (set 0) 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 selects 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. A SA command with parameters will turn on the error light, but otherwise is ignored.

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). Shift-in and shift-out are particularly useful when a line of text must be composed of two character sets.

The Label Instruction LB

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

Syntax:

LB character string [ETX]

The label mode can be terminated only by sending the ASCII character (ETX) at the end of the character string. The means of doing this is computer dependent. With some computers, ETX (and other control functions such as carriage return and line feed), may be included inside the quotes of the label command. With other computers such control functions must be sent in binary format. In either case, control functions included in a label command prior to the ETX character will be executed by the plotter as specified in the ASCII code definition in Appendix B.

On most computers, literal text is specifed in a label command by enclosing it in quotes. Here is an example of text in a label command.

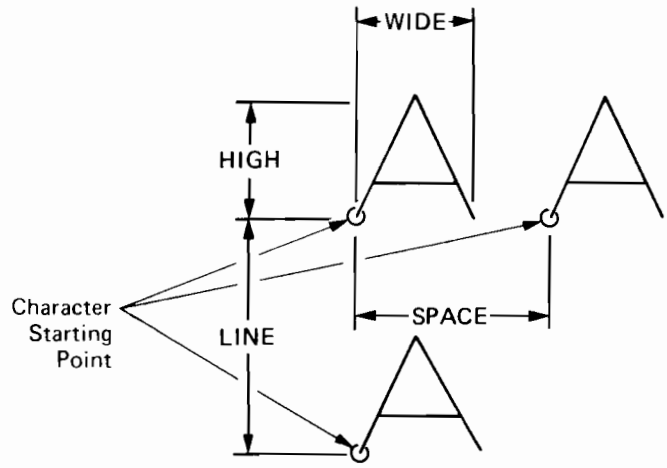
Send:

```
LBI AM A 7225A PLOTTER↳
```

Result:

I AM A 7225A PLOTTER

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 or 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 6.

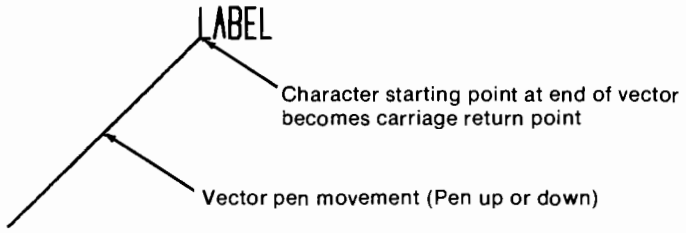


The direction, size, and slant of the characters being lettered assume default values if not previously specified by the commands DI, DR, SI, SR, or SL.

The character set used is designated by the commands CA and/or CS, and then selected by the commands SA or SS, the ASCII control characters shift-in or shift-out, or the default standard set. If not specified, the default character set is set 0.

When the plotter receives a carriage return character while in label mode, it returns to a defined carriage return point. The carriage return point is affected by any vector group instruction, direction instructions DI or DR, or by direction controls on the plotter front panel as follows.

Vector Group Instruction — all labeling performed after a vector instruction will have the carriage return point referenced as follows:



Direction Instructions — all labeling performed after a DI or DR command will have the character starting point of the first labeled character as the carriage return reference point unless otherwise changed.

Direction Controls — all labeling performed after pen movement by the direction controls is the same as the vector group instruction above.

Labeling With Variables

In some applications, it is necessary to label the plot using variables rather than literals to define the label string. Many different conventions are used in computers to define variable length and the character field format in which these variables will be printed. To avoid unexpected placement of the labels defined by variables, refer to your computer manual for a definition of the conventions used to define the output character field.

Quotation marks are used by many computers to define the literal characters that are to be sent, but variables are not included within quotation marks. The comma delimiter between variables or literals is used by some computers to cause the output to be left-justified in a specific character field width. The unused positions in this field are normally sent as blank spaces and will establish fixed spacing between label strings. For close spacing of the label strings, the blank spaces can normally be suppressed by substituting a semicolon delimiter between variables or literals.

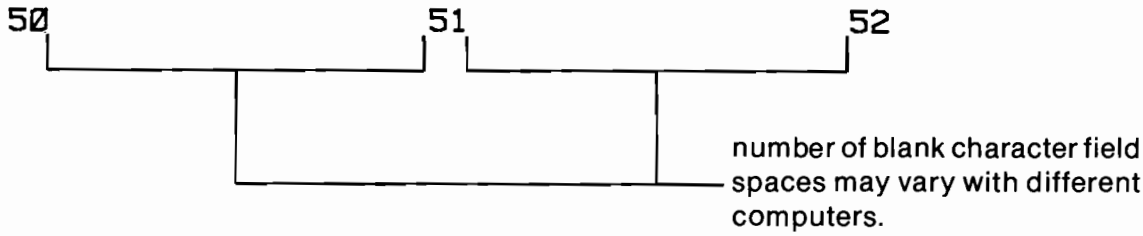
The following example illustrates the comma convention when using variables for labeling. HP-GL mnemonics and delimiters are enclosed in quotation marks.

Send:

```
LINE 1.  X=50
LINE 2.  ""LB"",X,X+1,X+2,""␣""
```

This statement causes the plotter to label the integer, integer + 1, and integer + 2. Blank spaces between the printed integers vary from computer to computer and normally include the sign space. A computer may or may not print positive signs.

Result:



The following example illustrates the semicolon convention when using variables for labeling:

Send:

```
LINE 1.  X=50
LINE 2.  ''LB'';X;X+1;X+2;''↵''
```

The semicolons between the variables cause suppression of blank spaces. The space between the printed integers varies with different computers, but normally includes the sign space.

Result:

```
50  51  52
```

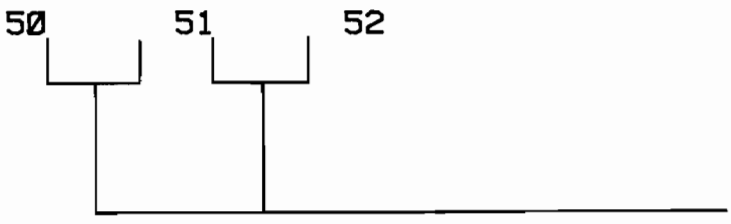
Any spaces required to fit into the context of the item being labeled must normally be sent enclosed in quotes. The following example labels the same variables as above, but with four extra spaces between each of the integers.

Send:

```
LINE 1.  X=50
LINE 2.  ''LB'';X;''    '';X+1;''    '';X+2;''↵''
```

Note that four spaces enclosed in quotes are sent between each variable; but the semicolon suppresses unwanted blank spaces.

Result:



The Absolute Direction Instruction DI

The absolute direction instruction DI specifies the direction in which characters are lettered.

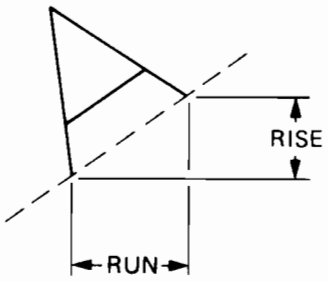
Syntax:

DI run, rise [; or LF]

Run and rise are in decimal format (0 ±127.999) and specify the direction according to the relationship:

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

where



A change of scaling 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).

A DI command with a rise parameter of zero will produce horizontal labeling. A DI command with a run parameter of zero will produce vertical labeling. At least one parameter must be effectively non zero (| parameter | ⩾0.004). A DI command with invalid parameters will turn on the error light and the direction of labeling will not change.

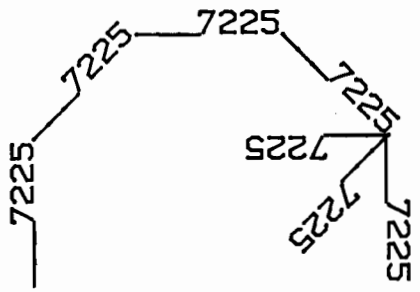
A DI command remains in effect until another DI or DR command is executed, or the plotter is initialized or set to default conditions.

The following example letters the word 7225 in a circular pattern, starting with vertical lettering. The direction in which each line is labeled is changed by 45 degrees. The last three lines include a carriage return before leaving label mode. Note that the carriage return point is the beginning of that label which is the carriage return point established by the DI instruction. (See the LB instruction, Chapter 6.)

Send:

```
LINE 1. PA2000,6000;
LINE 2. DI0,1;LB7225
LINE 3. DI1,1;;LB7225
LINE 4. DI1,0;LB7225
LINE 5. DI1,-1;LB7225
LINE 6. DI0,-1;LB7225
LINE 7. DI-1,-1;LB7225
LINE 8. DI-1,0;LB7225
```

Result:



The Relative Direction Instruction DR

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

Syntax:

DR run,rise [; or LF]

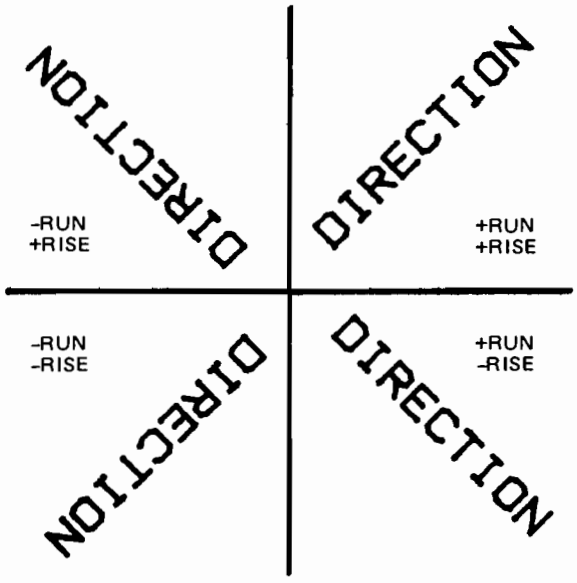
Run and rise are decimal numbers and specify the direction according to the relationship:

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

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.

If you imagine the current pen position to be the origin, the sign of the parameters determines in which quadrant the lettering will be.

In the example below rise and run assume all combinations of ±1 with default P1 and P2.



The algorithm used is more accurate with parameters greater than 1. While DR2, 3 and DR .02, .03 have the same ratio, rise/run, use of the former command is recommended to avoid unexpected results caused by roundoff error.

A change in P1 and P2 will affect the direction of the lettering.

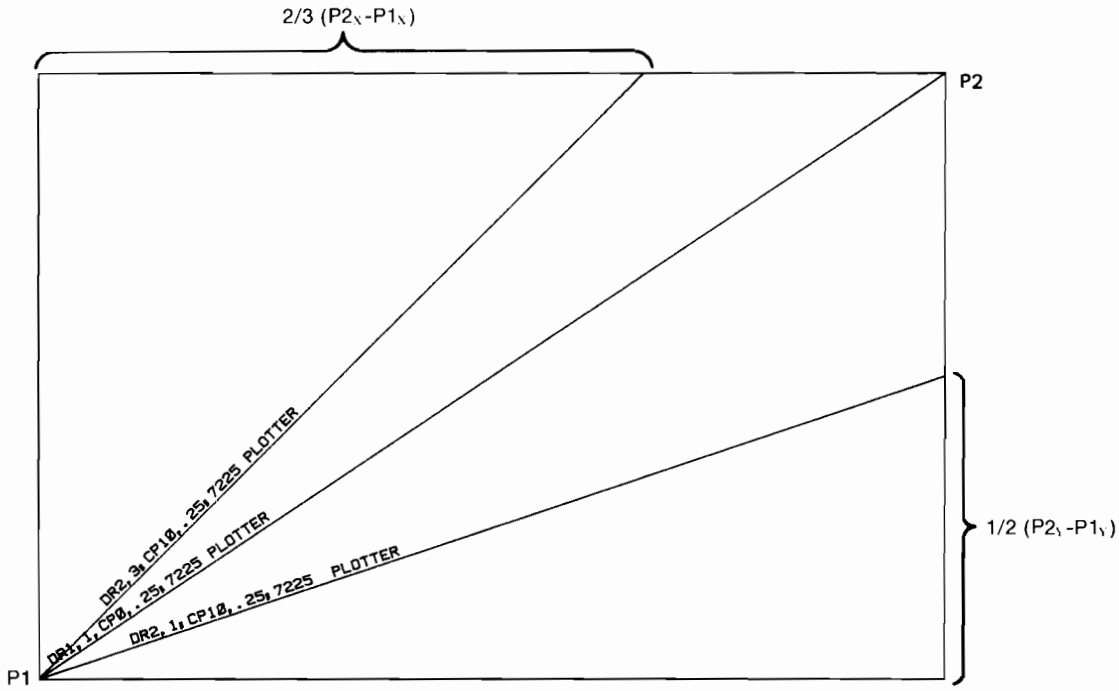
A DR command remains in effect until another DR or DI command is executed or the plotter is initialized or set to default conditions. A DR command with no parameters (DR;) defaults to DR 1,0 (horizontal lettering).

The following description may help you visualize the direction of labeling using the DR command with various parameters. Think of directional lines as being parallel to a line starting at the physical lower left scaling point and intersecting the opposite side or the top edge of the plotting area established by the current P1 and P2.

Form a fraction in lowest terms ≤ 1 using the run and rise parameters. If run = rise the fraction will equal 1 and the directional line will go from P1 to P2. If run $>$ rise the directional line will intersect the side of the plotting area that fraction of the way up toward P2. If rise $>$ run the directional line will intersect the top of the plotting area that fraction of the way across toward P2. Remember since lettering starts at the current pen position, labels will be parallel to these lines, not necessarily along them.

The accompanying program illustrates the DR command with a given P1 and P2.

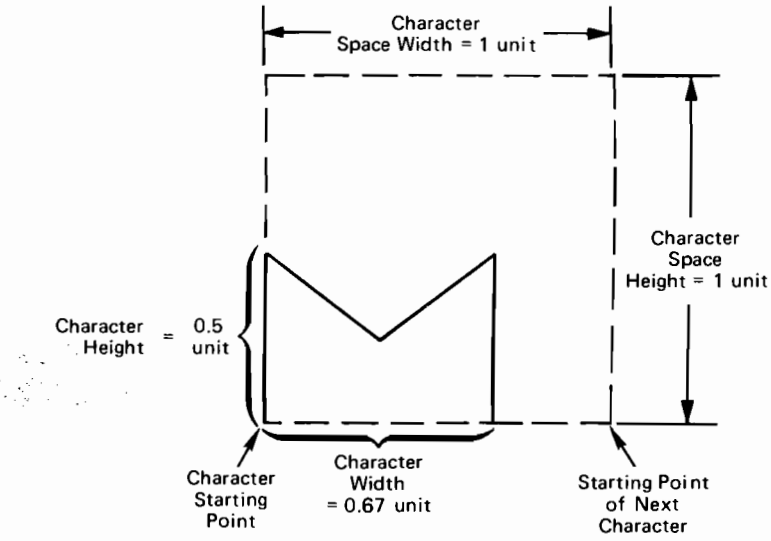
```
LINE 1. IN;IP1000,1000,10000,7000;PA1000,1000;PD;
LINE 2. PR9000,0,0,6000,-9000,0,-0,-6000;PA10000,7000;
LINE 3. PU;PA1000,1000;DR1,1;CP2,.25;LBDR1,1;CP0,.35;7225 PLOTTER
LINE 4. PU;PA1000,1000;PD;PA7000,7000;PU;
LINE 5. DR2,3;PA1000,1000;CP10,.25;LBDR2,3;CP10,.25;7225 PLOTTER
LINE 6. PU;PA1000,1000;PD;PA10000,4000;PU;PA1000,1000;
LINE 7. DR2,1;CP10,.25;LBDR2,1;CP10,.25;7225 PLOTTER
```



6

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. 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 1½ times the character's width. The space above and beside a drawn character becomes the spacing between lines and characters. The character space is illustrated below:



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 a character space.

The Absolute Character Size Instruction SI

The absolute charcter size instruction SI specifies the size of characters and symbols in centimetres.

Syntax:

SI width, height [; or LF]

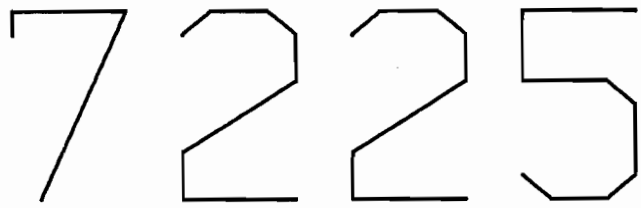
The defined width and height must be in decimal format and may have any value between 0 and +127.999. An SI command with no parameters (SI;) will default to the values 0.19 for width and 0.27 for height.

An SI command remains in effect until another valid SI or SR command is executed or the plotter is initialized or set to default conditions.

The following example labels the number 7225 at a specified width of 1.5 cm and height of 2.5 cm.

Send:


```
LINE 1. IN;PA1000,1000;
LINE 2. SI1.5,2.5;LB7225ETX
```



In order to produce legible characters, parameters should be greater than .1. Parameter values above 20 allow a maximum of one character on the platen area without involving the out of limit condition.

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]

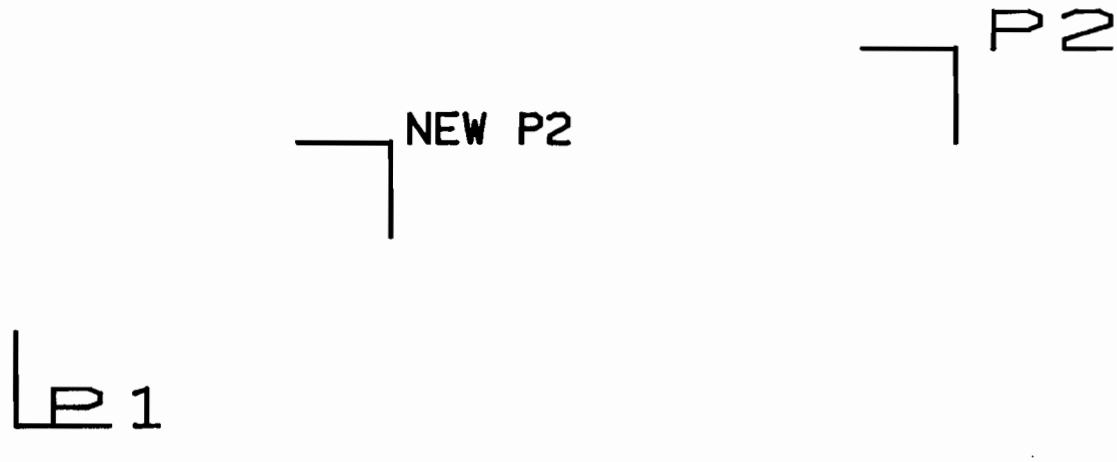
The width is the desired percentage (+0.004 to +127.999) of $|P2_X - P1_X|$, height is the desired percentage (+0.004 to +127.999) of $|P2_Y - P1_Y|$, and P1 and P2 are the scaling points.

An SR command with no parameters (SR;) will default to the same values as SR.75,1.5. Negative and zero parameters are invalid and will cause the error light to be turned on and use of the last valid SR parameters, or the default values, if no SR or SI has been previously specified.

An SR command remains in effect until another valid SR or SI command is executed, or the plotter is initialized or set to default conditions.

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 6. With default P1 and P2, the useful range of width and height parameters which produces legible characters and labels of suitable length is 0.6 to 5. The following program uses the same SR statement with two different settings of P1 or P2.

```
LINE 1. IN;IP1000,1000,6000,3000;SR5,10;
LINE 2. PA1000,1000;PD;PR500,0,-500,0,0,500;PU;PR200,-500;LBP1
LINE 3. PA6000,3000;PD;PR-500,0,500,0,0,-500;PU;PR200,500;LBP2
LINE 4. IP1000,1000,3000,2500;PA3000,2500;PD;PR-500,0,500,0,0,-500;
LINE 5. PU;PR100,500;LBNEW P2
```



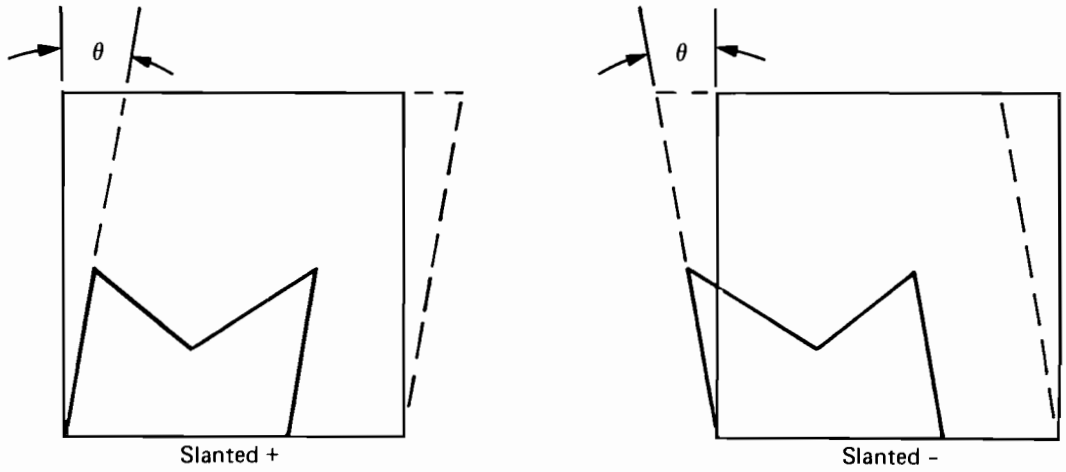
The Character Slant Instruction SL

The character slant instruction SL specifies the slant with which characters are lettered.

Syntax:

SL tan θ[; 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:



The useful parameter range is ±0.5 to ±2 when using default absolute character size and up to ± 3.5 for large letters.

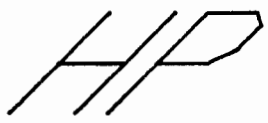
A change in scaling points P1 and P2 will not affect the angle θ.

An SL command with no parameters (SL;) will default to the same values as SL0 (no slant). An SL command with invalid parameters will turn on the error light and default to the last valid SL instruction, or if none to SL0. An SL command remains in effect until another valid SL command is executed or the plotter is reinitialized or set to default conditions.

The following example letters HP at a slant of +45°.

Send:

```
LINE 1. DF;IP200,200,3700,5500;SR10,10;
LINE 2. PA300,1000;SL1;LBHP
```



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:

1. Pen control parameters — sets pen status with an integer entry of +99 for pen down or -99 for pen up. Once a pen down (+99) has been sent, the pen will remain down for the following X and Y increment moves, until a pen up (-99) is sent or the UC command is completed. The pen control parameter is internal to the UC command. It does not affect pen status as set by the PU or PD instructions.

2. X increment — specifies the number of character grid units that the pen will move horizontally from the current pen position. 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 through +98 grid units.

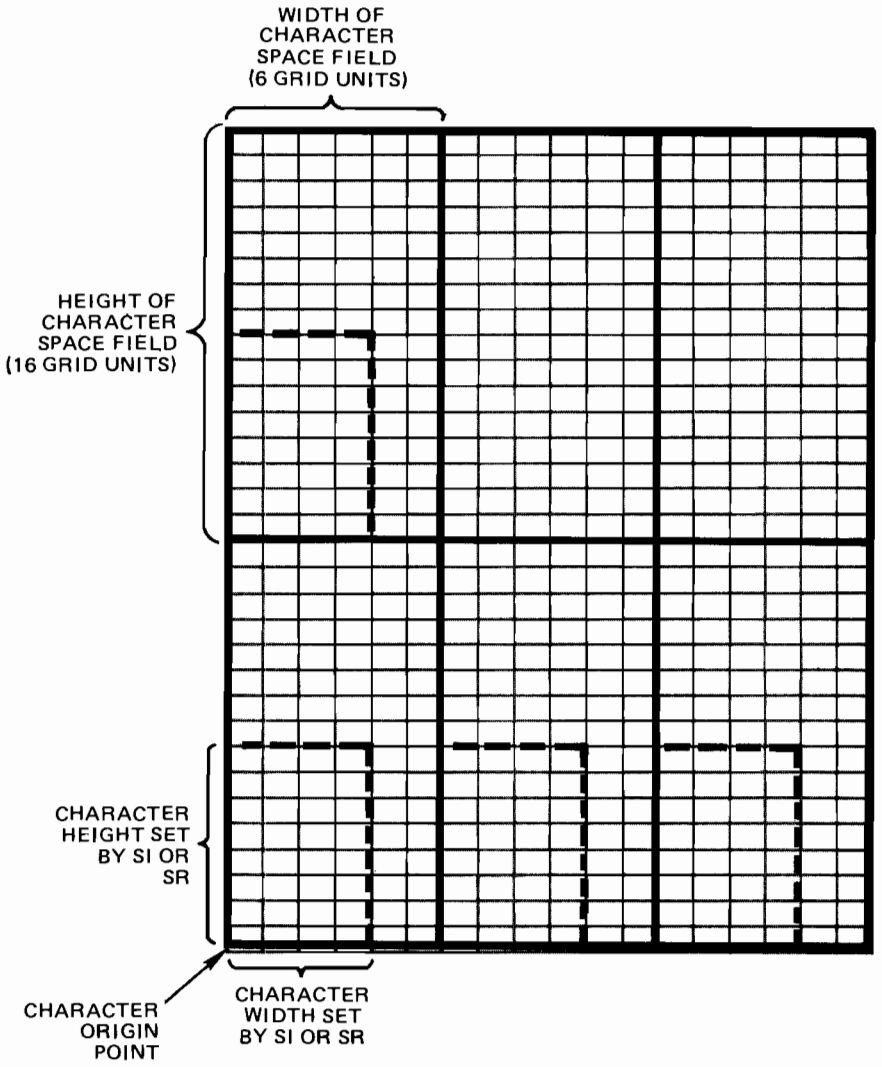
3. Y increment — specifies the number of character grid units that the pen will move vertically from the current pen position. A positive value moves the pen up and a negative value moves it down. The increment value must be an integer and can range from -98 through +98 grid units.

Use of integers outside the range-99 thru +99 will affect pen status in an unspecified manner.

Each character space field is divided into 6 horizontal grid units and 16 vertical grid units. Refer to Spacing Between Characters, Chapter 6. The size of the character space field and the grid units is set by the current size command (SI or SR) as shown below.

NOTE

The size of the character space field is always twice the character's height and 1½ times the character's width.



The position of the pen when the UC command is executed becomes the character origin point. The initial X,Y increment is relative to the character origin point and each subsequent move is relative to the last commanded pen position. Upon completion of the user defined character, the pen is automatically moved one character space field to the right of the character origin point. This point becomes the current pen position and hence the character origin point for the next character (if any).

Example of spaced oversize characters.

This example is identical to the last example, except that a CP instruction has been added to prevent the symbols from being superimposed.

Send:

```
LINE  1.  IN;PA1000,1000;
LINE  2.  FOR A=.19 TO .89 STEP .1
*LINE  3.  SI,A,A+.08
LINE  4.  UC-99,8,14,99,0,2,-8,0,4,-8,-4,-8,8,0,0,2;
LINE 4A.   CP1,0;
LINE  5.  NEXT A
LINE  6.  PA1000,2000;
LINE  7.  FOR B=.19 TO .89 STEP .1
*LINE  8.  SI,B,B+.08
LINE  9.  LBE;
LINE 10.  NEXT B
```

EEEEEEEEE

ΣΣΣΣΣΣΣΣΣ

Example of normal size user defined characters.

In the previous two examples, the symbol size is changed using the SI command. Other sizes can also be generated by dividing or multiplying the "UC" X,Y increment values. To demonstrate this feature, each of the X,Y increment values shown in the first example program has been divided by 2. Note that each symbol is only half as large as before and is now the same size as the E characters.

Send:

```
 LINE  1.  IN;PA1000,1000;
 LINE  2.  FOR A=.19 TO.89 STEP .1
*LINE  3.  SI,A,A+.08
 LINE  4.  UC-99,4,7,99,0,1,-4,0,2,-4,-2,-4,4,0,0,1;
 LINE  5.  NEXT A
 LINE  6.  PA1000,2000;
 LINE  7.  FOR B=.19 TO .89 STEP .1
*LINE  8.  SI,B,B+.08
 LINE  9.  LBE[Σ]:
 LINE 10.  NEXT B
```

EEEEEEEEE

ΣΣΣΣΣΣΣΣ

The Character Plot Instruction CP

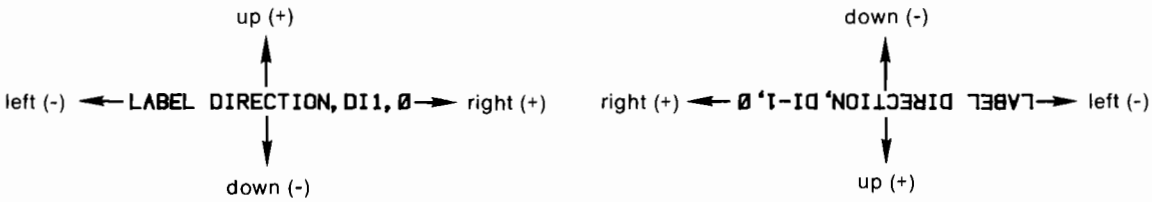
The character plot instruction CP moves the pen the specified number of character space fields.

Syntax:

> CP # of character space field widths, # of character space field 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 field 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, the plotter front-panel controls, or the pen position at the last DI or DR command. (See Label Instruction LB, Chapter 6).

When parameters are specified, the CP command moves the pen the specified number of character space field widths to the right (a positive value), or to the left (a negative value), and the number of character space field heights up (a positive value), or down (a negative value). Note that right, left, up, and down are relative to the label direction as shown below:

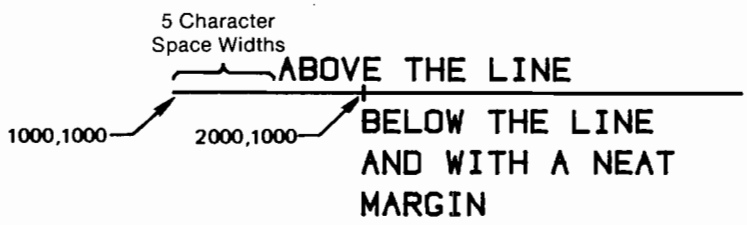


The pen's position (raised or lowered) does not change when a CP command is executed. The parameters must be within the range of ±127.999. However, since there are approximately 90 character space field widths and 40 character space field heights on the platen surface, assuming default sizing, the effective parameter range that will not invoke an out-of-limit condition is considerably less, depending on the pen position at the given time.

The CP; command is useful to produce lettering with alignment along a left-hand margin, while a CP command with small decimal parameters enables lettering along a line, but not on top of it. This is illustrated in the following program.

```
LINE 1. PA1000,1000;PD;PR3000,0;PU;PR-3000,0;
LINE 2. CP5,.35;LBABOVE THE LINE ETX
LINE 3. PA2000,1000;XT;CP0,-.95;LBBELOW THE LINE ETX
LINE 4. CP;LBAND WITH A NEAT ETX    CP;LBMARGIN ETX
```

The CP instruction in line 2 moves the label slightly above the line. The CP instruction in line 3 moves the label slightly below the line and the two CP instructions in line 4 perform a carriage return line feed to the margin established by the plot command in line 3.



Chapter 7

Plot Enhancement

This chapter describes the instructions that enable you to enhance the plotted data with axes and tick marks, special symbols, and programmable line types, and to change the pen velocity. Additional enhancement can be achieved by specifying drawing of a limited portion of a plot with the input window instruction.

The Tick Instructions XT and YT

The tick instruction XT draws a vertical X tick at the current pen location. The tick instruction YT draws a horizontal Y tick at the current pen location.

Syntax:

```
XT [; or LF]
```

or

```
YT [; or LF]
```

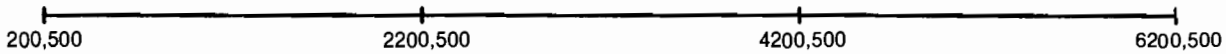
Neither instruction requires any parameters. Both instructions require the terminator ; or LF to complete the command.

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

The following example draws a horizontal line 6000 plotter units long, and places X ticks at the end points and at 2200 and 4200 X plotter units.

Send:

```
LINE 1.  IN;PA200,500;PD;XT;PR2000,0;XT;
LINE 2.  PR2000,0;XT;PR2000,0;XT;PU;
```



The Tick Length Instruction TL

The tick length instruction TL specifies 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. Since we normally think of this as being in the positive half of a graph, we call it tp.

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. Since we normally think of this as being in the negative half of the graph, we call it tn.

The values specified by parameters tp and tn are a percentage of the vertical scale length, $|P1_Y-P2_Y|$, when used with XT instructions, and a percentage of horizontal scale length, $|P1_X-P2_X|$, when used with YT instructions. Note that "actual tick length" is a function of the scaling established by P1 and P2, and the length of ticks on the X and Y axis will be different even if the same tick length percentage value is specified for both XT and YT unless the area defined by P1 and P2 is square.

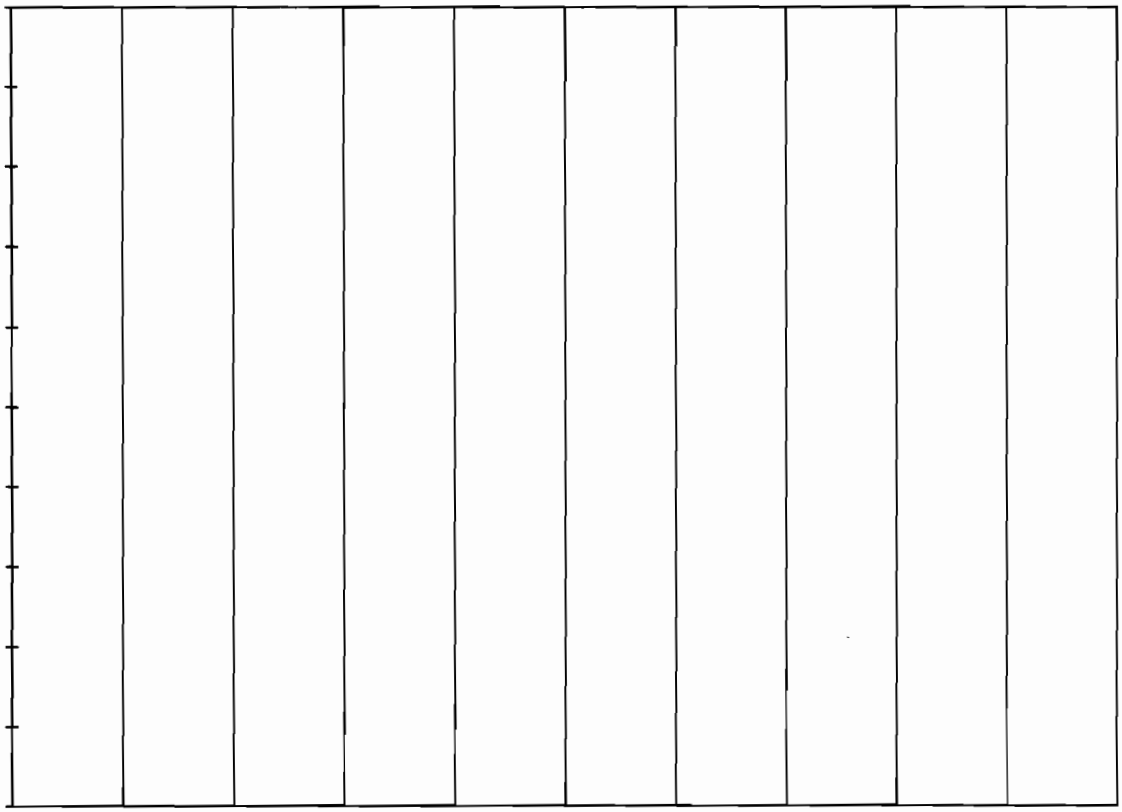
The plotter, when initialized, automatically sets the tick length values of 0.5% of the scaling lengths $|P2_Y-P1_Y|$, and $|P2_X-P1_X|$. The TL command with no parameters (TL;) will default to the same values. When only one parameter is included, it specifies the length of tp, and tn will be zero.

Both parameters must be between 0 and +127.999. Any TL command remains in effect until another TL command with valid parameters is executed or the plotter is initialized or set to default conditions.

The following program illustrates the use of the tick length instruction to draw both grid lines and tick marks. The grid lines are a result of specifying 100% tick length. Due to the IN instruction in LINE 1, P1 and P2 assume default values (P1=328,279 and P2= 10328,7479). Vertical grid lines are 7200 plotter units long. The resulting horizontal grid lines are 10000 plotter units in length (100% of 10328-328). The horizontal tick marks along the left-most grid line illustrate the default tp,tn length specified by the TL instruction in LINE 5. The line across the top of the plotting area is drawn using a tick length parameter of 100 again (LINE 9).

Send:

```
LINE 1.  IN;PA328,279;PD;TL100;XT;
LINE 2.  FOR I=1 TO 10
LINE 3.  PR1000,0;XT;
LINE 4.  NEXT I
LINE 5.  TL;PU;PA328,279;PD;YT;
LINE 6.  FOR J=1 TO 10
LINE 7.  PR0,720;YT;
LINE 8.  NEXT J
LINE 9.  TL100;YT;PU;
```



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 symbol is limited to a single character, which must be one of the centered characters of the character set chosen.

The PA and PR commands function as described in Chapter 5, except that the specified character is drawn at the end of each vector and is 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 character set currently selected when the SM instruction is executed. 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. If an invalid character is specified, error 3 is set and the symbol written does not change. The size (SI and SR), slant (SL), and direction (DI and DR) commands affect the character drawn. An SM command remains in effect until another valid SM command is executed or the plotter is intialized or set to default conditions.
All ASCII characters from decimal 35 through 122 can be specified except for the following:

ASCII Character	Decimal Value
%	37
&	38
'	39
(	40
)	41
/	47
:	58
;	59
<	60
=	61

ASCII Character	Decimal Value
>	62
?	63
@	64
[	91
\	92
]	93
^	94
_	95
`	96

Symbol mode can only be used with a single symbol. Whenever a label requires more than one symbol, CP instructions must be used.

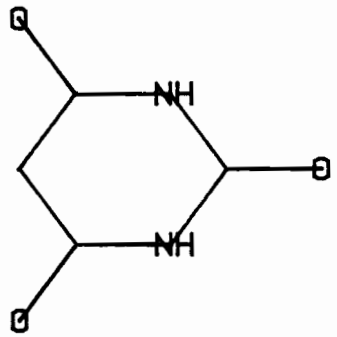
The following example uses symbol mode plotting combined with CP instructions and draws the barbituric acid molecule:

Send:

```
LINE 1. IN;PA5000,5000;PD;
LINE 2. PR300,400;SMO;PR-300,400;SM;
LINE 3. PR300,-400,500,0;PU;CP-.66,-.25;LBNH<ETX>CP-1.33,.25;
LINE 4. PD;PR300,-400;SMO;PR500,0;SM;
LINE 5. PR-500,0,-300,-400;PU;CP-.66,-.25;LBNH<ETX>CP-1.33,.25;
LINE 6. PD;PR-500,0;SMO;PR-300,-400;SM;
LINE 7. PR300,400,-300,400;PU
```

Since the symbol is drawn at the end of the vector, the symbol mode must be invoked prior to the vector move. In line 2, the symbol O is invoked prior to the move -300,400, and then cancelled (SM). Cancelling is required if the symbol is not to be drawn at the end of each vector.

Symbol mode can label only one character. In the molecule shown, in order to label the two characters NH, the label command together with the CP instruction (for centering) is required. This is shown in line 3 and line 5.



The program example under The Line Type Instruction (Chapter 7) illustrates use of both symbol mode plotting and line types.

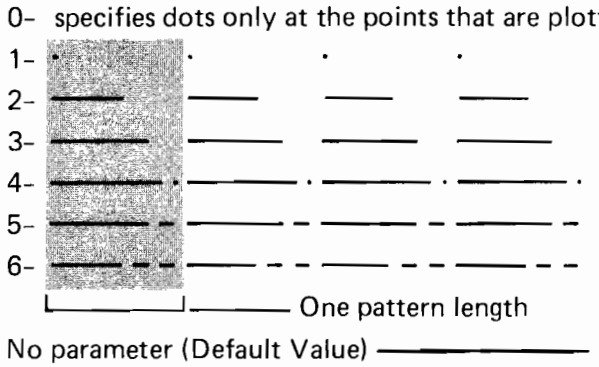
The Line Type Instruction LT

The line type instruction LT specifies 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.



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

The pattern number parameter is truncated to an integer. Parameters ≥7 set the error condition and the LT statement is ignored.

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, the last value received is used. If no pattern length has ever been specified, a length of 4% is used. Valid parameters are 0 to +127.999. Useful values for pattern length with default P1 and P2 are between 1 and 5 and depend somewhat on the pattern number.

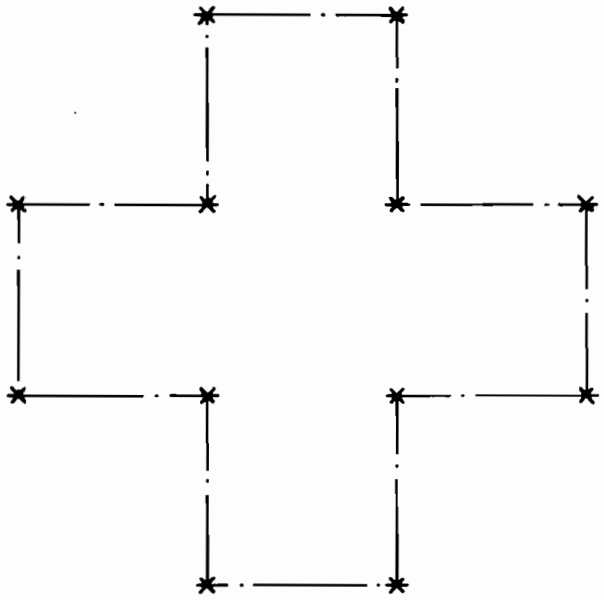
After this command, all subsequent vector commands with the pen down will cause the specified pattern to be drawn. Any portion of the pattern which is not used will be carried over into the next vector.

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

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

Send:

```
LINE 1.  IN;PA5000,5000;PD;LT4;SM*;PR1000,0,0,1000;
LINE 2.  PR1000,0,0,-1000,1000,0,0,-1000,-1000,0;
LINE 3.  PRO,-1000,-1000,0,0,1000,-1000,0,0,1000;PU;
```



The Velocity Select Instruction VS

The velocity select instruction VS specifies the pen speed for plotting and lettering operations.

Syntax:

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

The pen velocity parameter should be an integer between 1 and 25. It is an approximation of the pen speed in cm/s.

NOTE

The optional pen number is ignored by the 7225, and is included only for HP-GL compatibility with other HP plotters.

Velocity select is only in effect when the pen is down. Pen movement with the pen up is executed at 25 cm/s.

When the plotter is initialized, the pen velocity defaults to 25 cm/s. The VS command with no parameters (VS;), or with parameters greater than 25, but less than 128 also defaults the pen velocity to 25 cm/s. Parameters less than 1, or greater than 127 will cause an error and the pen velocity will not change.

A VS command remains in effect until another VS command with parameters between 1 and 127 is executed, or the plotter is initialized, or set to default conditions. VS 10 is recommended for plotting on transparency film.

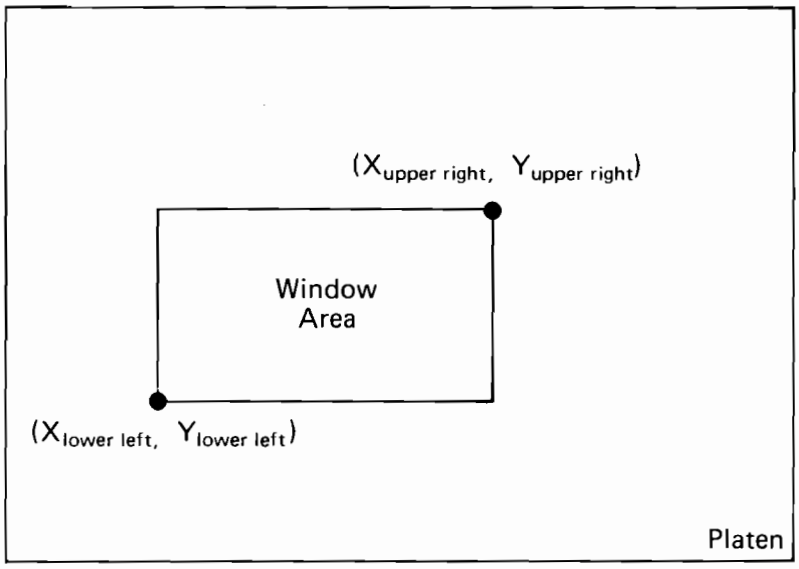
The Input Window Instruction IW

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. The parameters should be positive and less than 11420 for X and 8140 for Y. Parameters between -32767 and 0 are set to 0 and parameters larger than the platen area, but less than 32768 are set to limits of platen. Parameters beyond ±32767 will cause an error and the window will not change.



At power on, or upon execution of a DF or IN command, or if executed without parameters (IW;), the window is automatically set at the mechanical limits of the plotter. The OUT OF LIMIT light will come on, after execution of an IW command with parameters, if the current pen position is outside the area specified by the four parameters.

At this point, the reader may wish to review the concept of "nearby" and "faraway" as described under the Plot Absolute (PA) Instruction, Chapter 5.

There are in general seven 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 but "nearby"
3.	Inside window area	to	outside but "faraway"
4.	Outside window area but "nearby"	to	inside window area
5.	Outside window area but "nearby"	to	outside but "nearby"
6.	Outside window area but "faraway"	to	inside window area
7.	Outside window area "faraway"	to	outside window area but "nearby"

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 LIMIT light will come on steady.

In type 3, the pen will be raised, but not move, and the plotter will assume out-of-range condition (enter lost state). The OUT OF LIMIT light will come on blinking.

In type 4, the OUT OF LIMIT light is on steady 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 LIMIT light will go out, the pen will be under program control, either pen up or down as instructed, and will move to the new point.

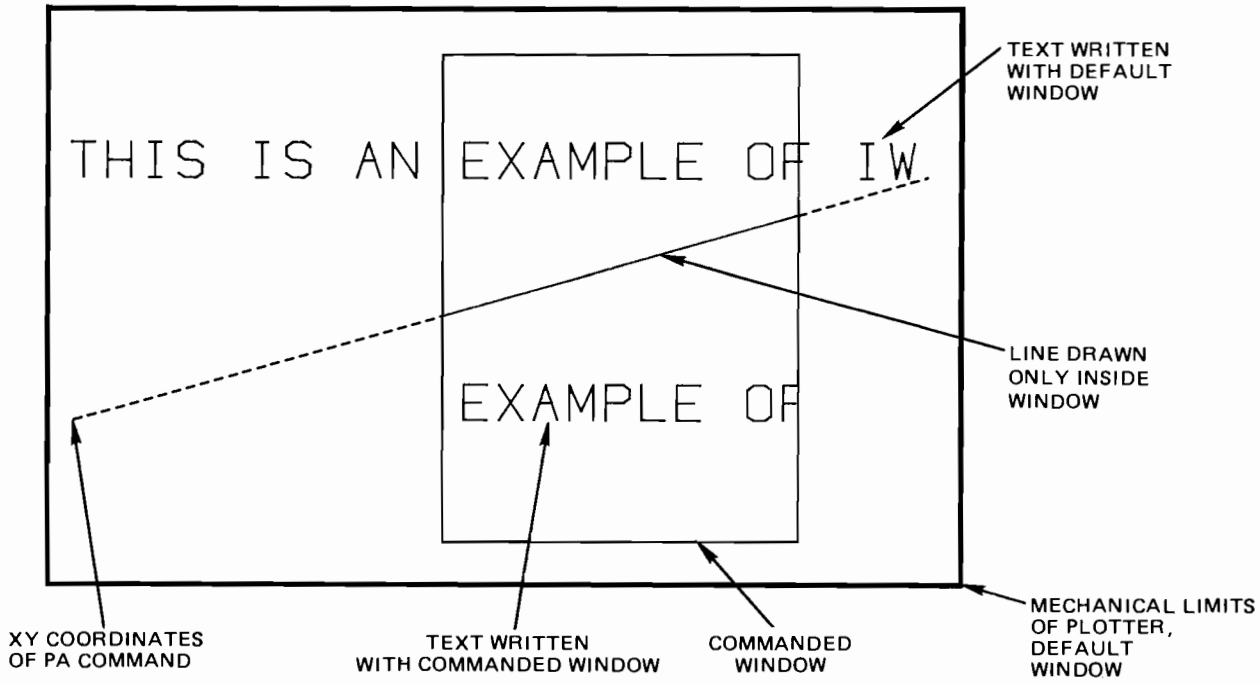
In type 5, the pen is raised and the OUT OF LIMIT light is on steady at the start of the vector. If part of the vector is in the window area, the plotter will move with the pen up to the intersection of the current vector and the window limit nearest the last point. The light will go out and pen will 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 LIMIT light will come on steady. If the vector from the last point to the new point does not intersect the window area, no move will be made. However X and Y coordinates of the current pen position are updated.

In type 6, the pen will move with pen up to the new point and the OUT OF LIMIT light will go out and the out-of-range mode (lost state) will be exited. Upon leaving the new point the pen will be under the control of the previous pen up or pen down instruction.

In type 7, the OUT OF LIMIT light will come on steady. If part of a vector from the last physical pen position to the new point is within the window area, the pen will move across the window with pen raised. If the vector from the last physical pen position to the new point does not intersect the window area, no move will be made.

In scaled mode a point will be within a window area, or outside but "nearby" or "faraway" if the plotter unit equivalents of the scaled parameters are within or outside that area.

The illustration below shows the effect of a window on text and plotted lines. The upper text is written with the default window (mechanical plotter limits) in effect. An IW command defining the rectangular area shown is executed. The pen is commanded to plot with the pen down to a point near the lower left corner. Only the portion of the line inside the window is drawn. When a label command to write the same text is given, only that portion within the window is written.

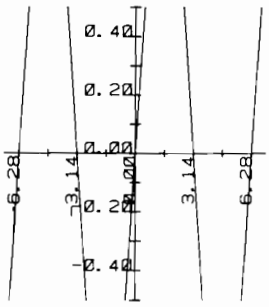


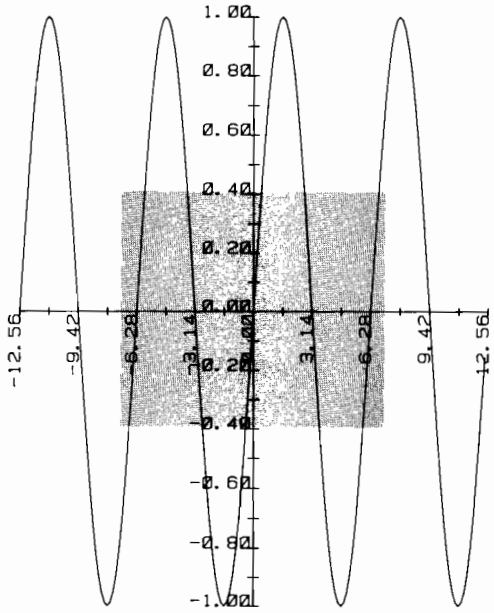
The input window command can be used to specify a limited portion of the plot. The following example plots the function sin X from -4π to 4π and -1 to 1. The same program is then run, but with the window command inserted after IN; in line 1, to demonstrate the "windowing" effect.

```
LINE  1.  IN;PA328,4000;PD;XT;
LINE  2.  FOR Xinterval =1 TO 16
LINE  3.  PR400,0;XT;
LINE  4.  NEXT Xinterval
LINE  5.  PU;PA328,4000;DIO,1;CP-6,0;
LINE  6.  FOR Xlabel =-12.56 TO 12.56 STEP 3.14
*LINE  7.  LB Xlabel ETX CP-6,0;PU;PR800,0;
LINE  8.  NEXT Xlabel
LINE  9.  PA3528,500;PD;YT;
LINE 10.  FOR Yinterval =1 TO 20
LINE 11.  PR0,350;YT;
LINE 12.  NEXT Yinterval
LINE 13.  PU;PA3528,500;DI;CP-6,0;
LINE 14.  FOR Ylabel =-1 TO 1 STEP .2
*LINE 15.  LB Ylabel ETX CP-6,0;PU;PR0,700;
LINE 16.  NEXT Ylabel
LINE 17.  FOR X =-4*PI TO 4*PI STEP PI/20
LINE 18.  Xcoord =6400/25.12*X+3528
LINE 19.  Ycoord =3500*SIN(X) +4000
*LINE 20.  PA Xcoord,Ycoord;PD;
LINE 21.  NEXT X
LINE 22.  PU;PA11420,8140;
```

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

```
IW1528,2250,5520,5200;
```





Chapter 8
Digitizing

This chapter describes the instructions used when the plotter is functioning as a digitizer or when you output the plotter's pen position.

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 a DP command 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 and sets bit position 2 of the output status word.

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 makes 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. This instruction should not be used in listen-only mode.

The OD command is used only when a digitized point has been stored, as indicated by receipt of the output status byte with a true (1) condition on bit position 2 (see Output Status Instruction, Chapter 3).

The pen position and status will be output to the computer as ASCII integers in the form:

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 ranges of the X and Y coordinates are the mechanical limits of the plotter; i.e. $0 \leqslant X \leqslant 11420$, $0 \leqslant Y \leqslant 8140$.

Upon receipt of the OD command by the plotter, bit position 2 of the output status byte is cleared.

The Output Actual Position and Pen Status Instruction OA

The output actual position and pen status instruction OA makes the X and Y coordinates and pen status (up or down) associated with the actual pen position available for output.

Syntax:

OA [; or LF]

No parameters are used, however the terminator ; or LF must be included to complete the command. This instruction should not be used in listen-only mode.

The OA command can be used with scaling on or off. (Use OD when in digitize mode).

After receipt of an OA command, the pen position and status will be output to the computer as ASCII integers in the form:

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 are $0 \leqslant X \leqslant 11420$, $0 \leqslant Y \leqslant 8140$.

The Output Commanded Position and Pen Status Instruction OC

The output commanded position and pen status instruction OC makes 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. This instruction should not be used in listen-only mode.

The OC command can be used with scaling on or off. (Use OD when in digitize mode). This instruction is especially useful when the pen is physically at the plotting limits and the physical pen position does not coincide with the commanded position, or when output in user units is desired.

After receipt of an OC command, the pen position and status will be output to the computer as ASCII integers in the form:

X , Y , P CR LF

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

When scaling is off the X and Y coordinates are in absolute plotter units. When scaling is on, the X and Y coordinates are in user units. The plotter will output a negative sign for negative numbers; positive signs are suppressed. The range of both X and Y coordinates is ±32767 whether scaling is on or off.

Digitizing with the 7225

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 computer. Digitizing cannot be done while the plotter is in listen-only mode. A special digitizing sight is available from HP or your dealer which allows you to visually position the pen over the point to be digitized. The sight is loaded like a pen and is used in the pen down position.

In general, the DP command is used with the OS and OD commands. The output status command OS is explained in Chapter 3. 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. Develop a FOR-NEXT loop with the total number of points digitized.

3. Enter the digitize mode, output the status byte, and monitor bit position 2 of the status byte for a true (1) condition. The true condition indicates that the 

pushbutton has been pressed.

4. Output the digitized point to the computer.

5. Continue the loop for all digitized points; then print or display the values for each digitized point if desired.

The following subroutine monitors bit position 2 of the status byte. Executing successive divisions of a number by two and checking for an odd or even integer answer, is a common way of monitoring bits without converting the number to binary form. This subroutine, if called after a digitize (DP) command, would accomplish steps 3 and 4 of the previous paragraph.

```
LINE 1. OS;
LINE 2. (using a suitable input statement, read the status byte into the variable
        named Status)
LINE 3. Status=INT(Status/2)
LINE 4. Status=INT(Status/2)
LINE 5. Status=Status MOD 2
LINE 6. IF Status=0 THEN Line1
LINE 7. OD;
LINE 8. RETURN
```

Chapter 9
Putting The Commands To Work

This chapter demonstrates the use of the 7225 commands to develop and label plots. Previous programs have purposely been kept to a less-advanced level in order to clearly demonstrate the command usage.

This example is a problem encountered in an engineering environment — the response of a system to a step input. However, the 7225 also provides excellent graphics for business applications as well as many other areas. Following the example provided should help you visualize the steps needed to prepare your finished plot.

Problem:

Scale, draw, and label X and Y-axes in user units and plot the function

$$d = 1000\ (1 - e^{-100t} \cos 300t).$$

Then, varying the line type, plot the function

$$d = 1000\ (1 - e^{-60t} \cos 300t)$$

over the limits $0 \leqslant t \leqslant 0.05, 0 \leqslant d \leqslant 1600$.

Finally, from a file of test data, again varying the line type, plot the test data on the same graph for comparison with the ideal curves.

Solution:

A. Position the plot. The 7225 has a range of $0 \leqslant X \leqslant 11420$ plotter units and $0 \leqslant Y \leqslant 8140$ plotter units. Allowing an additional 10% beyond the default P1 and P2 settings (P1 = 328,279 and P2 = 10328,7479) for labelling below the X-axis and to the left of the Y-axis, we set the scaling points to P1 = 1328, 1000 and P2 = 9328, 6760 using the IP instruction.

LINE 1. `IN;IP1328,1000,9328,6760;`

Note the use of the initialize instruction IN; in line 1. Either IN; or DF; should be included in all programs to reset parameters to their default values, thereby avoiding unexpected results caused by parameters inherited from a previously run program.

B. Scale the plotting area.
Although we could plot in plotter units, an easier method is to use the scale instruction SC to scale the plotting area into integer user units. We choose the scaling so as to cover the range of X and Y values and give sufficient resolution to our plot.
We know our data will cover the range $0 \leqslant X \leqslant 0.05$, and $0 \leqslant Y \leqslant 1600$. Had we not known this, we would have to make an educated guess about the range and perhaps revise the program after we saw a sample plot. Since the 7225 can only plot integers, we need to use a multiplier to convert the data to integers and to achieve sufficient resolution to obtain a smooth plot. We break the X axis into 500 units and the Y axis into 1600 units with the SC instruction below:

LINE 2. `SC0,500,0,1600;`

Since 10000 X 0.05 = 500 (the maximum scaled range) our X-multiplier to be used in calculations is 10000. No Y-multiplier is necessary since our results fall into the scaled range.

C. Draw, label and title the X-axis.

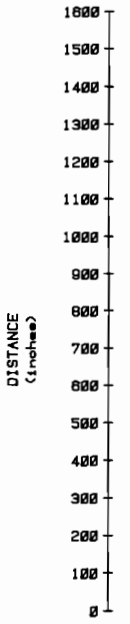
To draw and label the X-axis, we use a FOR-NEXT loop. The loop contains plot instructions, tick instructions, label instructions and the CP instruction to position the label. Because we want our output to read in hundredths of seconds to match our test data, we divide the user-unit position by our multiplier when writing the label. The title is written by line 9 after completion of the FOR-NEXT loop.

```
  LINE 3.  PAØ,Ø;PD;
  LINE 4.  FOR X=Ø TO 5ØØ STEP 1ØØ
✱LINE 5.  PAX,Ø;XT;PU;
✱LINE 6.  CP-2.4,-.9;LB,X/1ØØØØ,ETX
✱LINE 7.  PAX,Ø;PD;
  LINE 8.  NEXT X
  LINE 9.  PU;PA 2ØØ,-125;LBTIME (seconds)ETX
```

D. Draw, label and title the Y-axis

The Y-axis drawing and labeling is very similar to that of the X-axis, except that, since we will plot in integer units compatible with the results of our equations, there is no need to alter the label parameter before writing it.

```
  LINE 10.  PAØ,Ø;PD;
  LINE 11.  FOR Y=Ø TO 16ØØ STEP 1ØØ
✱LINE 12.  PAØ,Y;YT;PU;
✱LINE 13.  CP-4.9,-.3;LB,Y,ETX
✱LINE 14.  PAØ,Y;PD;
  LINE 15.  NEXT Y
  LINE 16.  PU;PA-55,6ØØ;DIØ,1;LBDISTANCE SI LI (inches)ETX
```



E. Plot the function

To define a smooth curve, the step size for t in the equation has been set to 0.0005, establishing 100 intervals along the X-axis. With the SC instruction used earlier, we could make the step size one-fifth this size, but this is not necessary to create a smooth plot with this particular equation. The equation of the function must be written in a form acceptable to your computer. The following instructions plot the equation

$$d = 1000\ (1-e^{-100t}\cos 300t)$$

```
LINE 17.  PA0,0;PD;
LINE 18.  FOR T=0 TO .05 STEP .0005
LINE 19.  Y=1000*(1-EXP(-100*T)*COS(300*T))
LINE 20.  X=T*10000
*LINE 21. PA X,Y;
LINE 22.  NEXT T
```

The pen moves to the locations defined by X and Y. Changing the line type for trace differentiation, the following instructions plot the equation

$$d = 1000\ (1-e^{-60t}\cos 300t)$$

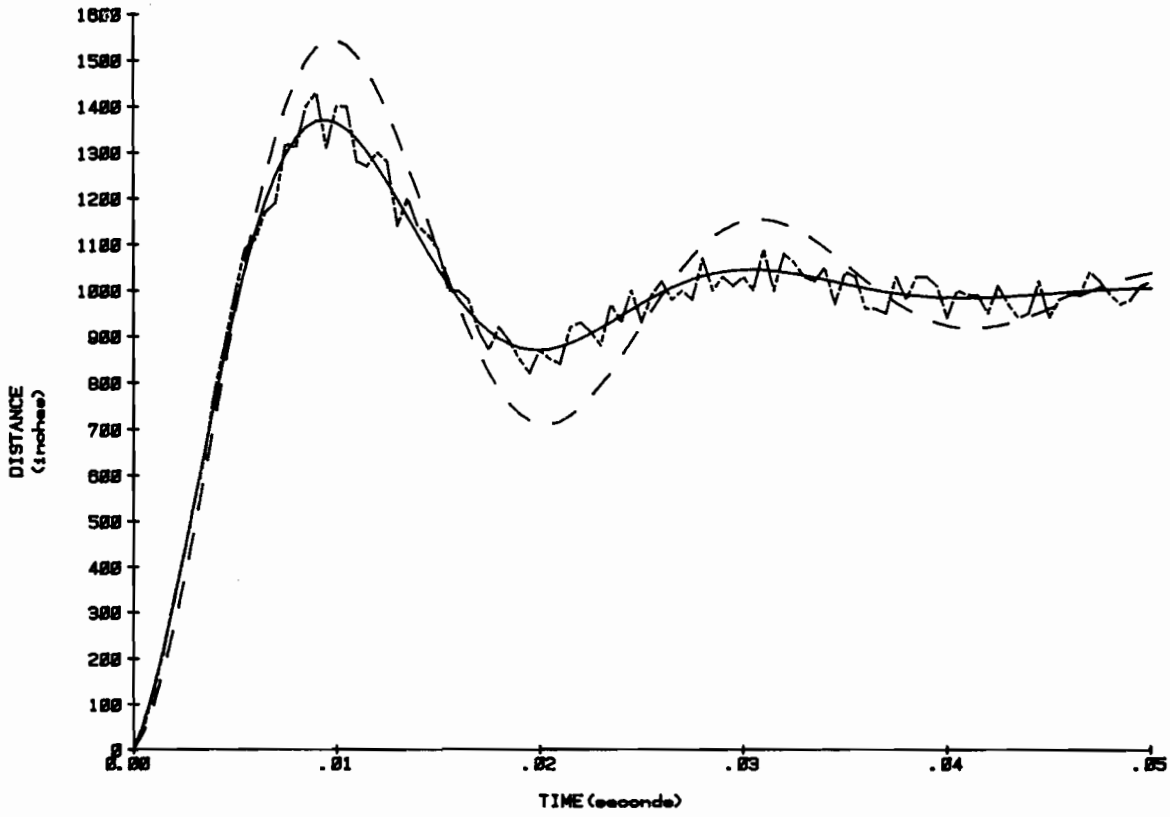
```
LINE 23.  PU;PA0,0;PD;LT2;
LINE 24.  FOR T=0 TO .05 STEP .0005
LINE 25.  Y=1000*(1-EXP(-60*T)*COS(300*T))
LINE 26.  X=T*10000
*LINE 27. PA X,Y;
LINE 28.  NEXT T
```

F. Intermediate results

Combining the previous instructions we obtain a plot of the labeled axes and the two curves.

```
 LINE  1.  IN;IP1328,1000,9328,6760;
 LINE  2.  SC0,500,0,1600;
 LINE  3.  PA0,0;PD;
 LINE  4.  FOR X=0 TO 500 STEP 100
*LINE  5.  PA X,0;XT;PU;
*LINE  6.  CP-2.4,-.3;LB,X/10000,ETX
*LINE  7.  PA X,0;PD;
 LINE  8.  NEXT X
 LINE  9.  PU;PA 200,-125;LBTIME(seconds)ETX
 LINE 10.  PA0,0;PD;
 LINE 11.  FOR Y=0 TO 1600 STEP 100
*LINE 12.  PA0,Y;YT;PU;
*LINE 13.  CP-4.9,-.3;LB,Y,ETX
*LINE 14.  PA0,Y;PD;
 LINE 15.  NEXT Y
 LINE 16.  PU;PA-55,600;DI0,1;LBDISTANCE CR LF(inches)ETX
 LINE 17.  PA0,0;PD;
 LINE 18.  FOR T=0 TO .05 STEP .0005
 LINE 19.  Y=1000*(1-EXP(-100*T)*COS(300*T))
 LINE 20.  X=T*10000
*LINE 21.  PA X,Y;
 LINE 22.  NEXT T
 LINE 23.  PU;PA0,0;PD;LT2;
 LINE 24.  FOR T=0 TO .05 STEP .0005
 LINE 25.  Y=1000*(1-EXP(-60*T)*COS(300*T))
 LINE 26.  X=T*10000
*LINE 27.  PA X,Y;
 LINE 28.  NEXT T
```

```
LINE 24.  FOR T=0 TO .05 STEP .0005
LINE 25.  Y=1000*(1-EXP(-60*T)*COS(300T))
LINE 26.  X=T*10000
*LINE 27.  PA X,Y;
LINE 28.  NEXT T
LINE 29.  PU;PA0,0;PD;LTG;
LINE 30.  FOR T=0 TO .05 STEP .0005
LINE 31.  READ Ydata
LINE 32.  Y=Ydata*10000
LINE 33.  X=T*10000
*LINE 34.  PA  X, Y
LINE 35.  NEXT T
LINE 36.  PU;
LINE 37.  DATA 0,.005,.013,.022,.033,.043,.054,.064,.078
LINE 38.  DATA .088,.099,.109,.111,.117,.12,.132,.13,.14
LINE 39.  DATA .143,.131,.14,.14,.128,.127,.13,.128,.114
LINE 40.  DATA .12,.114,.11,.109,.1,.1,.098,.091,.087
LINE 41.  DATA .092,.089,.085,.082,.087,.085,.084,.082
LINE 42.  DATA .093,.091,.088,.097,.093,.1,.093,.099,.102
LINE 43.  DATA .098, .1,.098,.107,.1,.103,.101,.103,.1,.109
LINE 44.  DATA .1,.108,.106,.103,.102,.105,.097,.104,.103
LINE 45.  DATA .096,.096,.095,.103,.098,.103,.103,.101
LINE 46.  DATA .094,.1,.099,.099,.095,.101,.097,.094,.095
LINE 47.  DATA .102,.094,.098,.099,.098,.104,.102,.099
LINE 48.  DATA .097,.098,.101,.102
```



Appendix A
An HP-IB Overview

The HP Interface Bus (HP-IB) provides an interconnecting channel for data transfer between devices on the HP-IB.

The following list defines the terms and concepts used to describe HP-IB (bus) system operations.

HP-IB System Terms

1. Addressing — The characters sent by a controlling device specifying which device sends information on the bus and which device(s) receives the information.

2. Byte — A unit of information consisting of 8 binary digits (bits).

3. Device — Any unit that is compatible with the ANSI/IEEE 488-1978 Standard.

4. Device Dependent — A response to information sent on the HP-IB that is characteristic of an individual devices design, and may vary from device to device.

5. Operator — The person that operates either the system or any device in the system.

6. Polling — The process typically used by a controller to locate a device that needs to interact with the controller. There are two types of polling:

   - Serial Poll — This method obtains one byte of operational information about an individual device in the system. The process must be repeated for each device from which information is desired.

   - Parallel Poll — This method obtains information about a group of devices simultaneously.

Interface Bus Concepts

Devices which communicate along the interface bus can be classified into three basic categories.

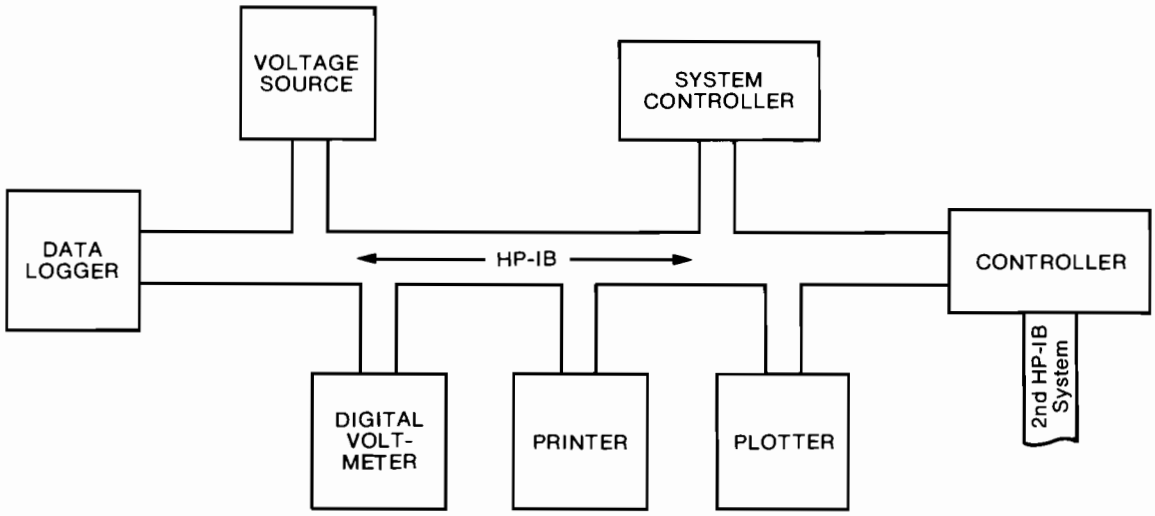
1. Talkers — Devices which send information on the bus when they have been addressed.

2. Listeners — Devices which receive information sent on the bus when they have been addressed.

3. Controllers — Devices that can specify the talker and listeners for an information transfer. Controllers can be categorized as one of two types:
   - Active Controller — The current controlling device on the bus. Only one device can be the active controller at any time.

   - System Controller - The only controller that can take priority control of the bus if it is not the current active controller. Although each bus system can have only one system controller, the system can have any number of devices capable of being the active controller.

A typical HP-IB System is shown below.



Message Concepts

Devices which communicate along the interface bus are transferring quantities of information. The transfer of information can be from one device to another device, or from one device to more than one device. These quantities of information can easily be thought of as "messages."

In turn, the messages can be classified into twelve types. The list below gives the twelve message types for the HP-IB.

1. The Data Message. This is the actual information which is sent from one talker to one or more listeners along the interface bus.

2. The Trigger Message. This message causes the listening device(s) to perform a device dependent action when addressed.

3. The Clear Message. This message causes either the listening device(s) or all of the devices on the bus to return to their predefined device-dependent states.

4. The Remote Message. This message causes listening devices to switch from local front-panel control to remote program control when addressed to listen.

5. The Local Message. This message clears the Remote Message from the listening device(s) and returns the device(s) to local front-panel control.

6. The Local Lockout Message. This message prevents a device operator from manually inhibiting remote program control.

7. The Clear Lockout/Local Message. This message causes all devices on the bus to be removed from Local Lockout and revert to Local. This message also clears the Remote Message for all devices on the bus.

8. The Require Service Message. A device can send this message at any time to signify that the device needs some type of interaction with the controller. This message is cleared by sending the devices's Status Byte Message if the device no longer requires service.

9. The Status Byte Message. A byte that represents the status of a single device on the bus. Bit 6 indicates whether the device sent a Require Service Message, and the remaining bits indicate operational conditions defined by the device. This byte is sent from a talking device in response to a serial poll operation performed by a controller.

10. The Status Bit Message. A byte that represents the operational conditions of a group of devices on the bus. Each device responds on a particular bit of the byte thus identifying a device-dependent condition. This bit is typically sent by devices in response to a parallel poll operation.

    The Status Bit Message can also be used by a controller to specify the particular bit and logic level that a device will respond with when a parallel poll operation is performed. Thus more than one device can respond on the same bit.

11. The Pass Control Message. This transfers the bus management responsibilities from the active controller to another controller.

12. The Abort Message. The system controller sends this message to unconditionally assume control of the bus from the active controller. This message terminates all bus communications (but does not implement a Clear Message).

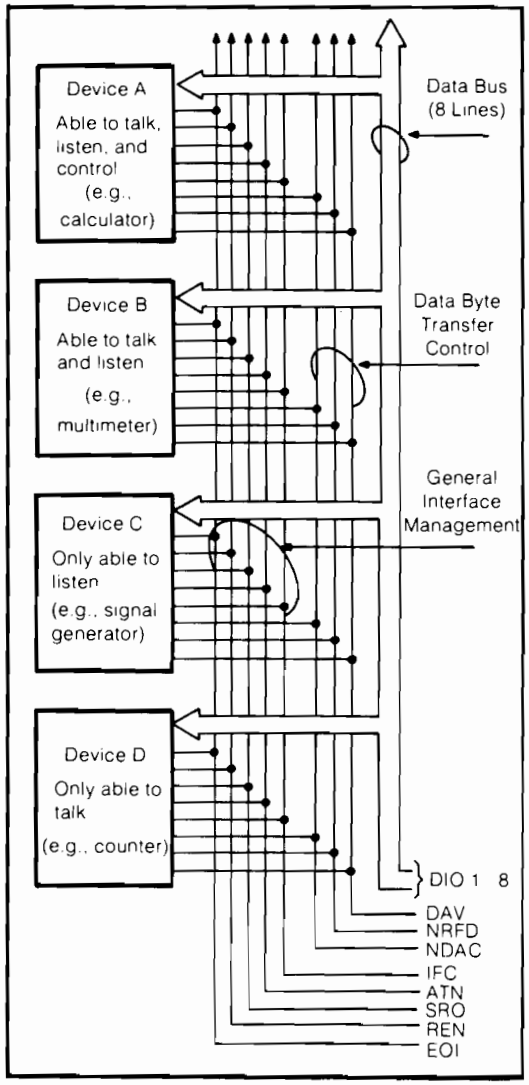
    These messages represent the full implementation of all HP-IB system capabilities. Each device in a system may be designed to use only the messages that are applicable to its purpose in the system. It is important for you to be aware of the HP-IB functions implemented on each device in your HP-IB system to ensure the operational compatibility of the system.

The HP Interface Bus

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 (DI01 thru DI08) 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 hand-shake 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.

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 messges 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, and a total of 31 allowable addresses are available in one byte. If all secondary commmands are used to extend this into a two-byte addressing capability, 961 addresses become available (31 allowable addresses in the second byte for each of the 31 allowable 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 Address
			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

HP 7225 HP-IB Implementation

1. Functions implemented (ANSI/IEEE 488-1978)

   a. Source Handshake (SH1)
   b. Acceptor Handshake (AH1)
   c. Talker (T2) Serial Poll
   d. Listener (L1)
   e. Service Request (SR1)
   f. No Remote Local (RL0)
   g. Parallel Poll (PP2)
   h. Device Clear (DC1)
   i. No Device Trigger (DT0)

2. 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.

Appendix B

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
$4 \times 10^1 + 1 \times 10^0$	$1 \times 2^5 + 0 \times 2^4 + 1 \times 2^3 + 0 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$
$40 \times 1 + 1 \times 1$	$1 \times 32 + 0 \times 16 + 1 \times 8 + 0 \times 4 + 0 \times 2 + 1 \times 1$
41_{10}	101001_2

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 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

= Binary 101001

Scaling Without Using the SC Instruction

The 7225 plotter movements are in terms of plotter units where 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 computer using the following equations:

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

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

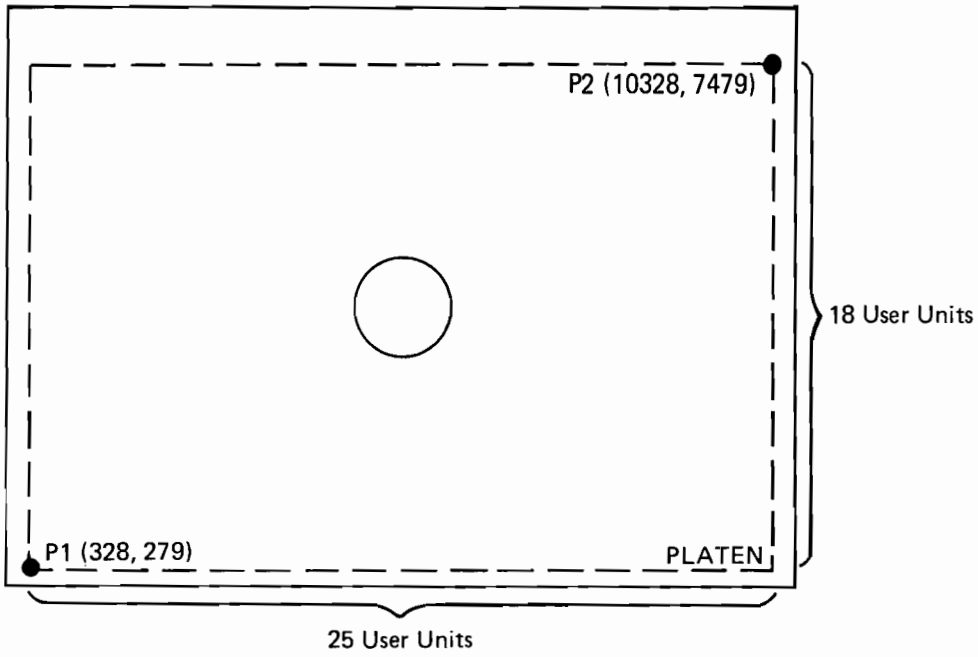
where: A_X is the X coordinate of the desired point in user units
A_Y is the Y coordinate of the desired point in user units.
$P1_X$ is the X coordinate of P1 in plotter units
$P1_Y$ is the Y coordinate of P1 in plotter units
$P2_X$ is the X coordinate of P2 in plotter units
$P2_Y$ is the Y coordinate 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 an example.

Example 1:

Problem

Scale the platen area (P1 = 328,279 and P2 = 10328,7479) into user units where P1 = 0, 0 and P2 = 25, 18 cm. At the center point (X = 12.5 Y, = 9 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

$$X_O = 12.5$$
$$Y_O = 9$$

C. The desired circle equations are then:

$$A_X = 2.5 \cos t + 12.5$$
$$A_Y = 2.5 \sin t + 9$$

D. Determine the user scale:

$$X = 0 \text{ to } 25$$
$$Y = 0 \text{ to } 18$$

therefore

$$U1_X = 0$$
$$U1_Y = 0$$
$$U2_X = 25$$
$$U2_Y = 18$$

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 +0.004 to +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 +0.004 to +127.999. If the parameters are omitted, default values are assumed.

Select Standard Character Set Instruction SS

SS [; or LF]

Parameters are not used.

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