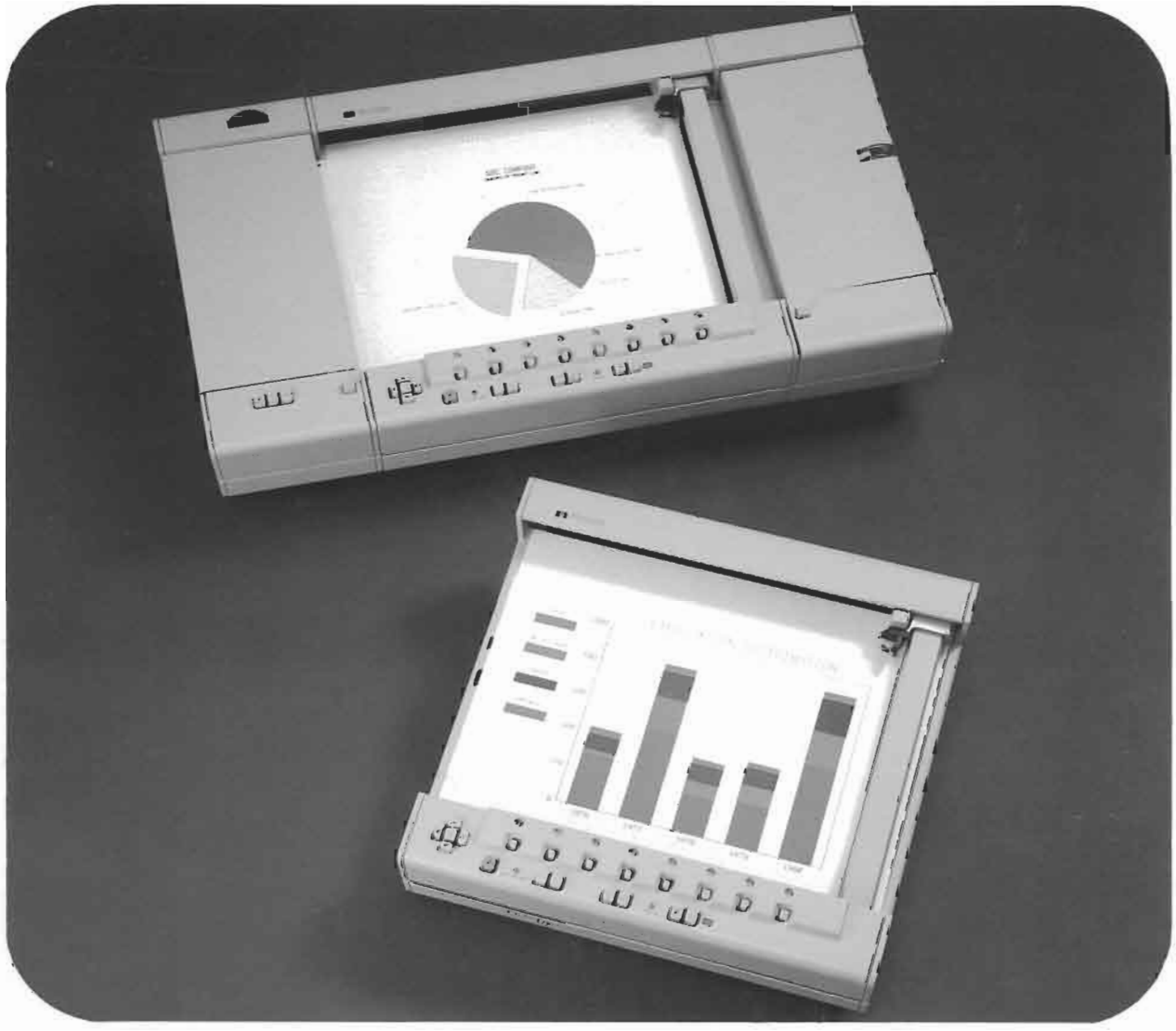
# 9872C Graphics Plotter and 9872T Graphics Plotter Operating and Programming Manual Using HP-GL Instructions

DESIGNED FOR HP-IB SYSTEMS



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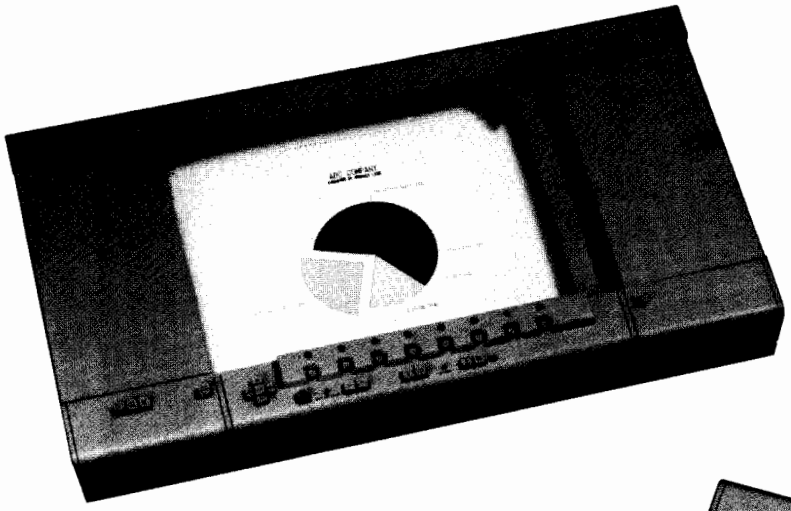
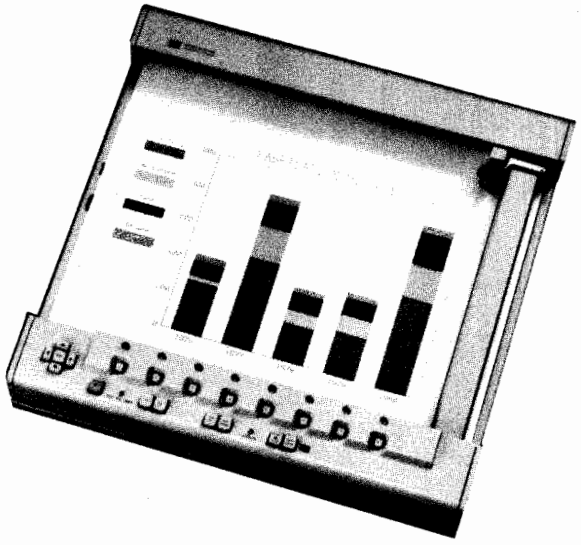


HP 9872T GRAPHICS PLOTTER



HP 9872C GRAPHICS PLOTTER


16399 W. BERNARDO DRIVE, SAN DIEGO, CALIFORNIA 92127 February 1982

9872-A-164-1

# Manual Summary

## Chapter 1: General Information

Information about setting up the plotter and its maintenance.

## Chapter 2: Plotter/Computer Communications

Describes how to interconnect the plotter and computer and the methods of addressing, sending, and receiving data over the Hewlett-Packard Interface Bus.

## Chapter 3: General Programming Instructions

Describes the 9872 instruction set, default conditions, initialization instructions, and general output instructions.

## Chapter 4: Scaling

Describes various unit systems available for describing the plotting area, instructions for locating the scaling points, and the scaling instruction.

## Chapter 5: Pen Control and Plotting

Describes instructions used in plotting and in controlling the pen.

## Chapter 6: Labeling Plots

Describes the plotter's internal character sets and the instructions used in labeling plots.

## Chapter 7: Plot Enhancement

Describes the instructions used to enhance plots.

## Chapter 8: Digitizing

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

## Chapter 9: Automatic Paper Advance

Describes the instructions for 9872T which advance and cut the paper.

## Chapter 10: Putting the Commands to Work

A step-by-step example illustrating the procedures to be followed to draw and label axes and plot data. Includes suggested programming practices.

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# Manual Summary (Continued)

## Appendix A:

Overview of the Hewlett-Packard Interface Bus (HP-IB)

## Appendix B:

Provides binary-to-decimal coding conversions, additional scaling formulas, error message definition, default settings/conditions, and a summary of the instruction syntax.

# Table of Contents

Chapter 6 (Continued)

Appendix B (Continued)

# Chapter 1
# General Information

## Introduction

This manual contains interfacing and programming information for the Hewlett-Packard 9872C and 9872T Graphics Plotters. The manual is organized into ten chapters and two appendices as follows:





Before using this manual, you should be thoroughly familiar with your computer and its programming language. The 9872C and 9872T are interfaced through the Hewlett-Packard Interface Bus (HP-IB conforms to ANSI IEEE 488-1978). Using the appropriate interface cable, you can connect the plotter to your HP-IB compatible desktop computer, computer, or other controller.

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

References to the 9872 plotter include both the 9872C and 9872T. When 9872 is followed by a letter, reference is being made to that model only.

Command Syntax

| | |
|---|---|
| DOT MATRIX | — All items in dot matrix are required exactly as shown, except that you may use lower case letters. |
| 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.

All program listings are printed in dot matrix characters. Lines in program listings are either BASIC statements or strings of HP-GL commands. Only the HP-GL commands should be sent to the plotter. The output statements necessary to do this are not included in the listings. BASIC statements such as FOR, NEXT, or assignment statements should not be sent to the plotter.

Some strings of HP-GL commands may require controller-dependent format statements in order to be accepted by the plotter. Lines requiring format statements and BASIC statements not sent to the plotter are noted with a ★ or ■ in each program listing.

## Description

The Hewlett-Packard 9872C and 9872T are microprocessor-based HP-IB plotters that produce high quality, multi-color graphic plots up to 285 × 400 mm (11.2 × 15.75 in.). The plotters are identical except for the automatic paper advance features of the 9872T.

Both the 9872C and 9872T accommodate chart paper up to ISOA3 (297 × 420 mm) and 280 × 432 mm (11 × 17 in.). In addition, the 9872T accommodates roll paper perforated at either ISOA3 or 11 in. width. The 9872T allows programmable or manually controlled full or half page paper advance. Since the paper cutter can be enabled or disabled programmatically or with a front panel switch, paper can be cut into ISOA3 or ISOA4 and 11 × 17 in. or 8½ × 11 in. sizes, or can be left uncut.

There are 43 different Hewlett-Packard Graphics Language (HP-GL) instructions built in to equip the plotter with such capabilities as point digitizing, labeling, character sizing, window plotting, and scaling. In addition, the 9872T recognizes three more instructions which control the automatic paper advance features. Using this easily understood HP-GL language, you can start plotting with a minimum of programming experience.

Trace identification is enhanced by the automatic selection of any of eight pens through either program control or front panel pushbuttons. Seven different dashed-line fonts, symbol mode plotting, and user-defined characters provide additional trace identification capabilities.

Fast, high quality plotting is another contribution of the 9872 plotter. Pen velocity is programmable to any one of 36 speeds from 10 mm/s to 360 mm/s (0.4 to 14.2 in./s), so quality graphics can be produced not only on standard paper but also on other media.

Annotation can be easily done using any of five character sets, including three European sets. Text can be written in any direction, with or without character slant, and in varying sizes. You can even design your own characters.

The 9872 family is engineered to be especially useful in the areas of business graphics, statistics, medicine, numerical control, surveying, and engineering design. An optional overhead transparency kit enables you to produce high quality graphic transparencies from your plotting programs. Project the details as you present economic trends, engineering or scientific data, marketing plans, profit data, or sales forecasts.

The 9872T, with software controlled paper advance and cutting, is designed to allow unattended operation in a laboratory or computer environment. This plotter is ideal for repetitive production of engineering test system output, mainframe computer room output, and production of multiple copies of presentation graphs in up to eight colors.

Whether data are tabulated, measured, or computed, the 9872 enables you to prepare multicolored plots of excellent line quality and high resolution.

## Unpacking and Inspection

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**WARNING**

The 9872T is a large, heavy device (weight 65 lbs.). Do not attempt to unpack it or move it to a different location alone.

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The 9872T plotter should be moved or unpacked by two people, one positioned at each end of the plotter. Each person should grasp the lower support bars of the plotter near the rubber feet and lift.

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 and file a claim with the carrier if the unit is received in a damaged condition.

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.

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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.

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**NOTE**

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 from HP.

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## Accessories Supplied

The following items are supplied with each 9872 plotter:

| Item | Quantity | Part Number |
|---|---|---|
| Operating and Programming Manual | 1 | 09872-90011 |
| Pocket Guide | 1 | 09872-90013 |
| Power Cord (appropriate cord supplied based on destination of unit) | | |
| Dust Cover 9872C<br>or<br>Dust cover 9872T | 1 | 9222-0742<br><br>9222-0741 |
| Digitizing Sight | 1 | 09872-60066 |
| Paper Tray 9872T only | 1 | 17072-60251 |
| Starter Kit* 9872C — includes: | 1 | |
| Plotter Paper, 8½ × 11 in. blank (pkg of 300 sheets) | 1 | 9280-0517 |
| Plotter Paper 11 × 16½ in., blank (pkg of 300 sheets) | | 9280-0518 |
| Fiber tip pens, package contains: | | |
| 5 black pens, 0.3 mm line width | 1 | 5060-6787 |
| 5 black pens, 0.7 mm line width | 1 | 5060-6890 |
| 4 pens, 0.3 mm line width, 1 each of black, red, blue, and green | 2 | 5060-6810 |
| 4 pens, 0.7 mm line width, 1 each of black, red, blue, and green | 1 | 5060-6858 |
| 6 pens, 0.3 mm line width, 1 each of burnt orange, lime green, gold, turquoise, violet, and brown | 1 | 5060-6894 |
| 6 pens, 0.7 mm line width, 1 each of burnt orange, lime green, gold, turquoise, violet, and brown | 1 | 5060-6895 |
| Starter Kit* 9872T — includes:<br>Same as 9872C Starter Kit *except* Roll Paper (English), 200 ft., perforated at 11 in. replaces 8½ × 11 in. blank paper. | 1 | 9280-0493 |

*Metric paper may be supplied with the plotter based on destination of unit. This will result in replacement of 8½ × 11 in. paper by A4 size 210 × 297 mm (9280-0519) and English roll paper by metric roll paper, 61 m perforated at 297 mm (9280-0494).

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# Accessories Available

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

| Item | Part Number |
|---|---|
| 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 |
| 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<br>1 each red, green, blue, black | 5060-6810 |
| Four-color Pack, 0.7 mm line width<br>1 each red, green, blue, black | 5060-6858 |
| Six-color Pack, 0.3 mm line width<br>1 each burnt orange, lime green, gold, turquoise, violet, brown | 5060-6894 |
| Six-color Pack, 0.7 mm line width<br>1 each burnt orange, lime green, gold, turquoise, violet, brown | 5060-6895 |
| Plotter Paper | |
| 10 × 15 in. grid area, 10 grids/in., 100 sheets | 9270-1004 |
| 7 × 10 in. grid area, 10 grids/in., 100 sheets | 9270-1006 |
| 250 × 380 mm grid area, 1 grid/mm, 100 sheets | 9270-1024 |
| 180 × 250 mm grid area, 1 grid/mm, 100 sheets | 9270-1023 |
| Semi-log: | |
| 10 in. × 2 cycle plot area, 100 sheets | 9280-0159 |
| 10 in. × 3 cycle plot area, 100 sheets | 9280-0160 |
| 2 cycle × 15 in. plot area, 100 sheets | 9280-0169 |
| 3 cycle × 15 in. plot area, 100 sheets | 9280-0168 |
| Log-log: | |
| 2 cycle × 3 cycle plot area, 100 sheets | 9280-0167 |
| 3 cycle × 2 cycle plot area, 100 sheets | 9280-0165 |
| 3 cycle × 4 cycle plot area, 100 sheets | 9280-0171 |
| Blank, 100 sheets 11 × 16½ in. | 9280-0180 |
| Blank, 300 sheets 11 × 16½ in. | 9280-0518 |
| Blank, 300 sheets 8½ × 11 in. | 9280-0517 |
| Blank, 300 sheets ISO A4 (210 × 297 mm) | 9280-0519 |
| Roll: English 200 ft. (61 m) perforated for 11 in. width | 9280-0493 |
| Metric 61 m (200 ft.) perforated at 297 mm | 9280-0494 |
| Overhead Transparency Kit (includes) | 17055A |
| Package of 4 pens, 0.3 mm line width, 1 each red, green, blue, black | 5060-6818 |
| Package of 4 pens, 0.6 mm line width, 1 each red, green, blue, black | 5060-6819 |
| Package of 4 pens, 0.3 mm line width, 1 each black, orange, brown, violet | 5060-6834 |
| Package of 4 pens, 0.6 mm line width, 1 each black, orange, brown, violet | 5060-6835 |
| Solvent 29.6 ml (1 fl. oz.) | 5060-6828 |
| 100 sheets transparency film (kit includes two packages) | 9270-0639 |

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## Accessories Available (Continued)

| 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 |
| Carrying case 9872C only (not suitable for shipping) | 1540-0480 |
| Interface Cables, ROMs and Software (see your HP sales representative) | |
| Service Manual 9872C/T | 09872-90012 |

Additional plotter supplies are available from your local Hewlett-Packard Sales and Service Office. Just ask for a copy of the Computer Supplies Catalog (5953-2450) 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 9872 plotter has the following power requirements:

- Line Voltage: 100 V ~ +5%, −10%
  120 V ~ +5%, −10%
  220 V ~ +5%, −10%
  240 V ~ +5%, −10%
- Line Frequency: 48 to 66 Hz, single phase
- Maximum Line Current: 1.3 A @ 100 V
  1.1 A @ 120 V
  600 mA @ 220 V
  550 mA @ 240 V
- Consumption: 100 Watts maximum

## Power Cords

Power cords with different plugs are available for the 9872. 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 the instrument has the wrong power cord for the area, please contact the local HP Sales and Service Office.

## Fuse

**CAUTION**

To prevent damage to the plotter verify that the line voltage selection is proper and install a fuse of the correct amperage and type BEFORE connecting the line power. Also ensure the line power cord is connected to a line power socket that is provided with a protective earth ground contact.

The 9872 is factory equipped with a fuse appropriate to the factory-set line voltage. To change or inspect the line fuse, turn the fuseholder on the rear panel in the direction of the arrow (counterclockwise) until the fuseholder releases. Remove the fuseholder and insert a slo-blo type T fuse which matches the voltage setting. Place the fuseholder back into the plotter, and turn the fuseholder clockwise, while pressing it, until the threads engage and the fuse remains flush with its casing. Fuse values appear below.

| Voltage | Fuse |
|---|---|
| 100 V or 120 V | 1.5 AT |
| 220 V or 240 V | 800 mAT |

## Line Voltage Selection

The 9872 is shipped from the factory with the line voltage set to the nominal value for the specified area. The line voltage can be changed by qualified service personnel only. Line voltage selection procedures are contained in the 9872C/T Service Manual HP Part Number 09872-90012.

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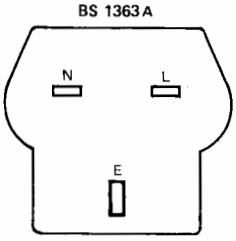
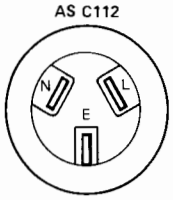
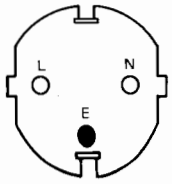
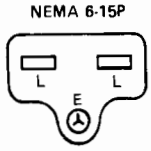
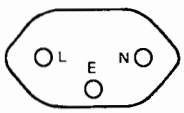
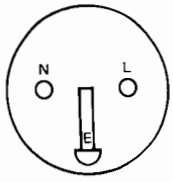
# Power Cord Configurations

| | | Option Number |
|---|---|---|
| BS 1363A   | HP Part Number 8120-1351; 250 V, 13 A, 1$\phi$ plug rating. (For use in United Kingdom, Cyprus, Nigeria, Rhodesia, Singapore) | 900 |
| AS C112   | HP Part Number 8120-1369; 250 V, 10 A, 1$\phi$ plug rating. (For use in Australia, New Zealand) | 901 |
| CEE 7-VII   | HP Part Number 8120-2857; 250 V, 10/16 A, 1$\phi$ plug rating. (For use in East and West Europe, Saudi Arabia, Egypt) | 902 |
| NEMA 5-15P   | HP Part Number 8120-1378; 125 V, 15 A, 1$\phi$ plug rating. (UL approved; for use in United States, Canada, Japan, Mexico, Philippines, Taiwan) | 903 |
| NEMA 6-15P   | HP Part Number 8120-0698; 250 V, 15 A, 1$\phi$ plug rating. (UL approved; for use in United States) | 904 |
| SEV 1011   | HP Part Number 8120-2104; 250 V, 10 A, 1$\phi$ plug rating. (For use in Switzerland) | 906 |
| DHCK-107   | HP Part Number 8120-2956; 250 V, 10 A, 1$\phi$ 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

# Operator Maintenance

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

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**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.



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## 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. Alcohol and water may be used to remove the remaining cleanser from the surface.

### Pen Stall Cleaning

Before using spectrum pens with the 9845C desktop computer or overhead transparency pens, remove leftover ink from the boots in the pen stalls using a cotton swab and solvent. This will prevent the transfer of other inks to the plots.

### Air Filter Cleaning

The air filter located on the rear panel 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.

If the plotter is being returned to Hewlett-Packard for any reason, contact your local HP Sales and Service Office for shipping instructions. 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. Model number and full serial number.

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

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**CAUTION**

Before shipping remove all pens.

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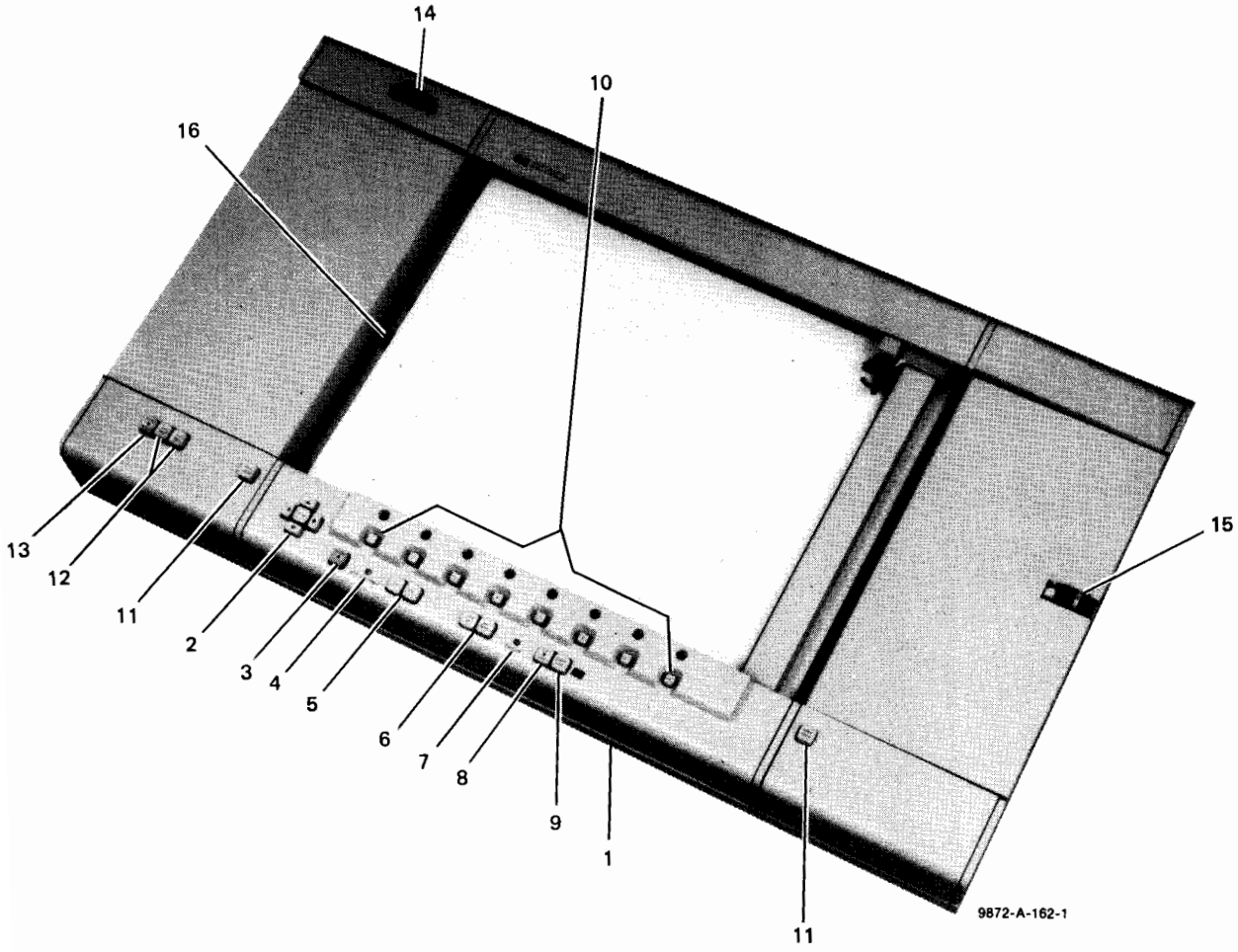


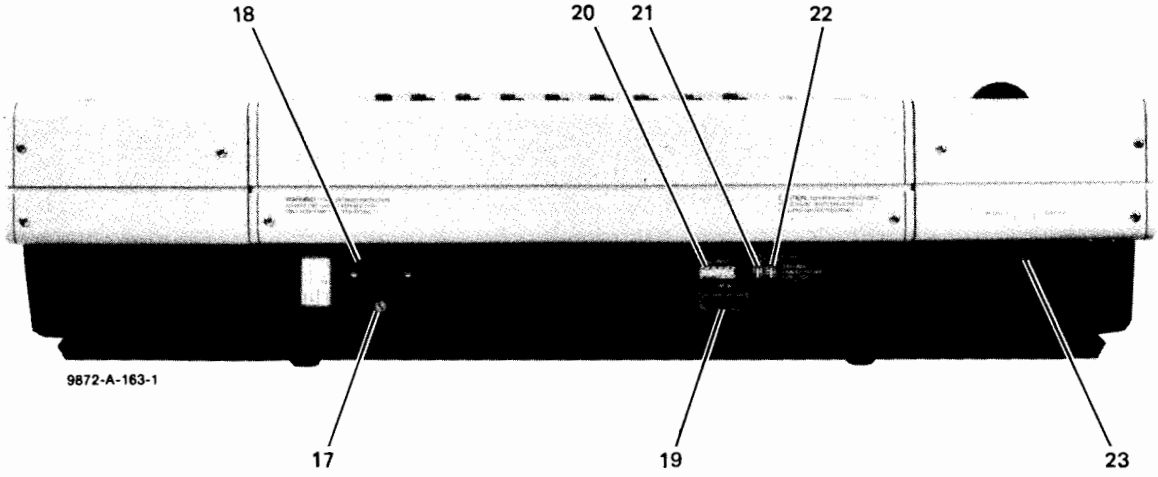


9872T Plotter Controls and Indicators

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# Controls and Indicators

A brief description of the 9872 controls and indicators, including their functions, follows. Those which apply to both the 9872C and 9872T are given first, followed by those that apply to the 9872T only.

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**WARNING**

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

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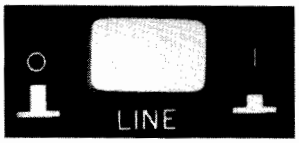
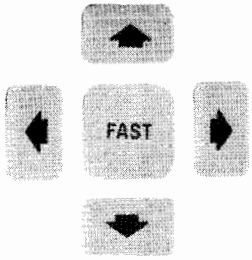
## FRONT BASE

1. 


A pushbutton switch that controls application of power to the plotter. Power is on when depressed (set to ⏽ ) and off when extended (set to ○ ).

## FRONT PANEL

2. 


Pushbuttons to move pen within the plotting area in the direction of the arrows at 4 mm/s. Two adjacent pushbuttons move pen diagonally in the indicated directions at 5.66 mm/s. When an arrow pushbutton is pressed together with [FAST], pen moves at approximately 90 mm/s and at 127 mm/s diagonally. May halt program and draw unwanted lines if pressed during program execution.

3. 


A multi-purpose pushbutton with a lamp. It is used as follows:

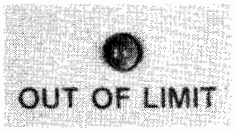
a. Pushed before [CHART HOLD] to initialize plotter. [ENTER •] lamp blinks until [CHART HOLD] is pushed.

b. Used with [P1] and [P2] to establish scaling points. [ENTER •] lamp blinks until [P1] or [P2] is pushed.

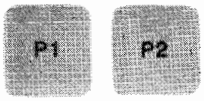
c. Used to enter a point in digitizing mode. [ENTER •] lamp is on steady from receipt of digitize point command until [ENTER •] button is pushed.

d. Used with the pen select buttons to store a pen.

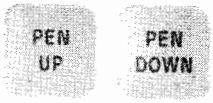
e. [ENTER] lamp can be turned off by pushing any of the [↑] [←] [→] [↓] pushbuttons.

4. 

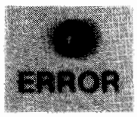

OUT OF LIMIT lamp lights when plotter is requested to plot outside window area or beyond limits of platen area. Lamp blinks if commanded position puts plotter in "lost" state. See Plot Absolute (Chapter 5) and Input Window (Chapter 7).

5. 


Pressing [P1] or [P2] raises the pen and moves it to the corresponding physical point, P1 or P2, on the platen. Pressing [ENTER], followed by [P1] or [P2] defines the current pen location as the scaling point P1 or P2. See Setting The Scaling Points (Chapter 4).

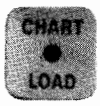
6. 


These pushbuttons raise or lower the pen. When held down during program execution, they override programmed pen control until released. [PEN DOWN] with [↑] [←] [FAST] [→] [↓] can be used to draw lines.

7. 


ERROR lamp lights when an error occurs if error mask has been set to flag that error. See Input Mask Instruction (Chapter 3).

Lamp also lights at end of confidence test until confidence test switch is turned off.

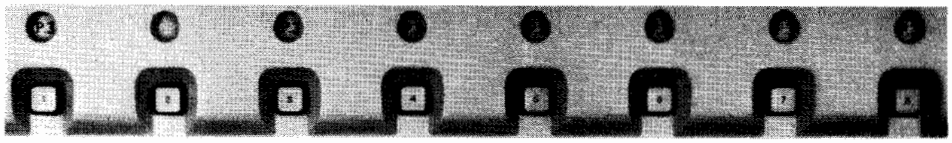
8. 


Pressing this pushbutton causes the pen to move to the upper right-hand corner of platen, turns on the lamp, and deactivates the paper hold-down.

9. 


A pushbutton that activates electrostatic paper hold-down when sheet paper is used, and turns off the [CHART LOAD] lamp. Cannot be activated when using roll paper on the 9872T.

When pressed after pressing [ENTER] the plotter is initialized.

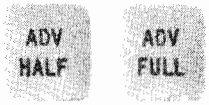
10. 

Pen select buttons for manual control of pen selection. Can be used to change a pen during program execution. The pen change is made after execution of the current instruction. Note pen coding is visible through round holes located above the pushbuttons.

**9872T ONLY**

11. 


Pushbuttons to release cover on right and left paper supply module.

12. 

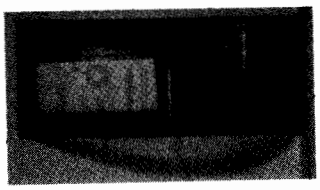

Pushbuttons to advance paper one full page or one half page from left margin of platen. The length of the advance depends on the setting of the English/metric switch on the rear panel. Will interrupt plotting and advance paper if pushed during program execution.

13. 


Pushbutton switch to enable/disable cutter. Lamp is on when cutter is enabled and off when disabled.

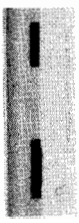
14. 

Paper advance thumbwheel to adjust tension on newly loaded roll paper or to advance paper manually.

15. 

Paper gauge calibrated in quarters of a roll.

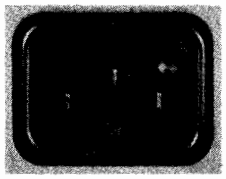
**PLATEN AREA**

16. 

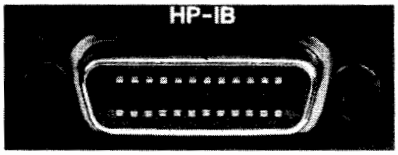
Paper stop. Should be recessed while roll paper is in use and raised when using sheet paper. Pushing upper part with a pencil point will raise stop.

## POWER PANEL 9872C AND 9872T

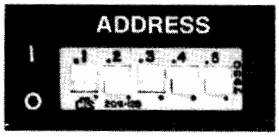
17.  Fuseholder. See Fuse (Chapter 1.)

18.  Power cord receptacle. See Power Cords (Chapter 1).

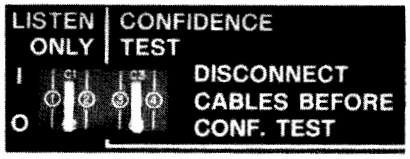
## I/O REAR PANEL

19. 

24-pin HP-IB interface connection for cable from computer or other HP-IB device.

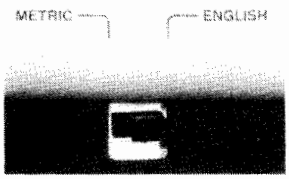
20. 

Plotter address switches set at HP-IB address for plotter. Set at 5 at factory. See Plotter Address Code (Chapter 2).

21. & 22. 

21). Listen only switch set to 0 for talk and listen mode and 1 for listen only mode.
22). Confidence test switch. See Confidence Test (Chapter 1).

## 9872T ONLY

23. 

Metric/English paper switch to control length of paper advance and settings of scaling point P1 and P2 at power-up and initialization.

1

# Setting Up The Plotter

## Determining Pen Type

To obtain plots of the highest quality, it is important to use pens matched to your application. Pens are available for use on standard Hewlett-Packard plotting paper, transparency film, and with the Spectrum Graphics Kit for the 9845C. The top of each pen is marked, in a color which matches the pen's ink, with a two-character code. The first character is alphabetic and denotes the media on which the pen will draw or the ink type. The P is for Paper, T for Transparency, and S for Spectrum pens which use subtractive inks. The second character is numeric and specifies in millimetres the approximate width of a line drawn with that pen.

## Turning the Power On

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

a. Pen moves to lower right corner with the pen up.

b. Chart hold is on. Chart hold is off if roll paper is loaded on a 9872T.

c. Certain parameters are set to their default values. For a description, see the DF instruction (Chapter 3).

## Loading Pens

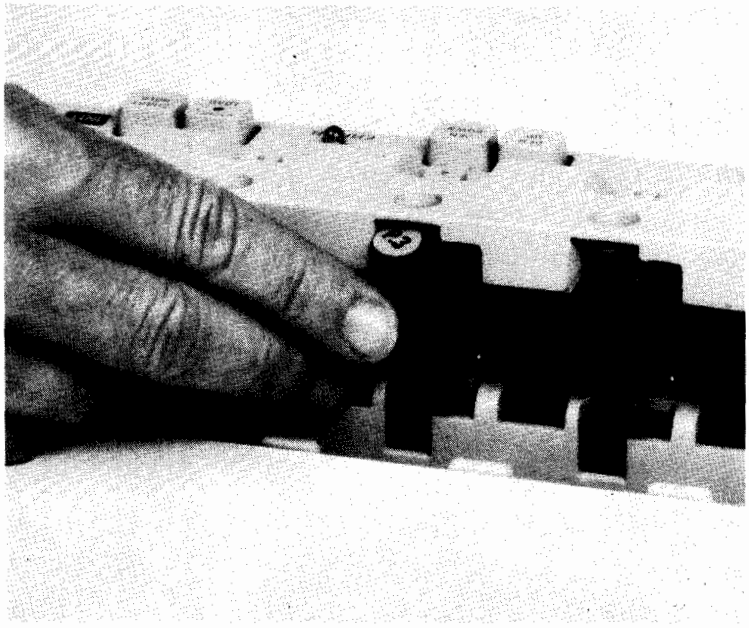
After the plotter's initialization process is complete and the plotter arm has stopped moving, you can install the pens. There are two methods of doing this. The first is to place the pen directly into the stable under the front panel; the second is to place each pen in the pen holder and store it using the front panel buttons.

### Direct Pen Storage

**WARNING**

To avoid the possibility of injured fingers, always turn the plotter off when directly storing pens.

Turn the plotter off. Select the pen to be placed in the first stall and remove the pen cap. Place the pen tip in the round boot at the base of the stall and press the pen down and in gently until the pen snaps into place. The pen code on the top of the pen will be centered under the hole in the front panel. Repeat this procedure for the remaining pens and turn the plotter back on.

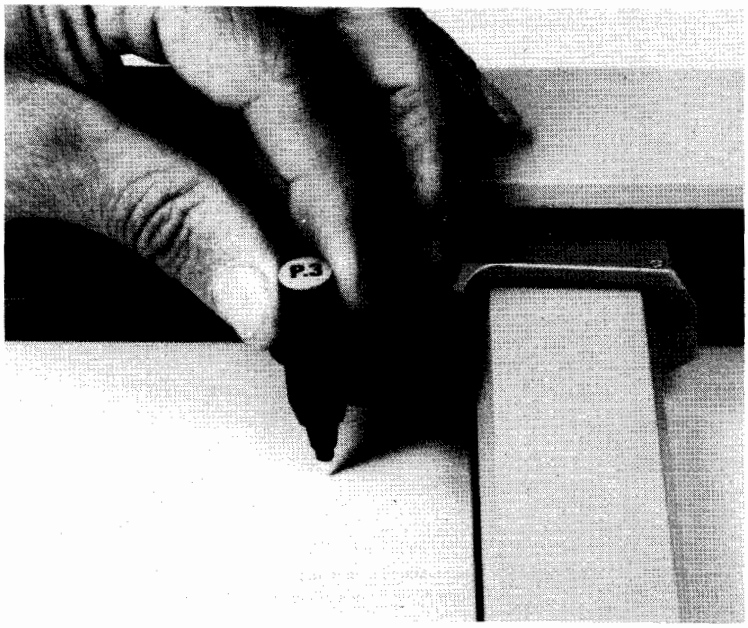


9872-A-166-1

With the plotter turned off for safety reasons, pens may be removed from a stable by depressing the lever to the right of the pen, grasping the pen between thumb and index finger and pulling gently.

**Automatic Pen Storage**

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




9872-A-165-1

1

## Loading Sheet Paper

To load sheet 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. Raise the paper stop by pushing down the upper portion of the stop with a pencil or other pointed object. Make sure the paper is positioned squarely against the ridge at the bottom of the platen and against the paper stop on the left side of the platen. Starting from the lower left corner, smooth the paper with the back of your hand so that skin oil is not deposited on the paper. Now press [CHART HOLD]. This will activate the electrostatic hold-down mechanism and turn off the lamp in [CHART LOAD]. Smooth the paper again with the back of your hand.

## Loading Roll Paper (9872T)

**WARNING**

To avoid the possibility of injured fingers, always turn off the plotter before changing roll paper.

Store pens to avoid getting ink on the new paper. Turn off the plotter to avoid injury and to disable electrostatic hold-down. Depress the paper stop on the left side of the platen and open both left and right paper supply modules by pressing the door latch buttons. Grasping the roll of paper in your left hand continue loading as follows (see pictures):

1. Load roll between hubs in supply module with paper feeding across top of roll, aligning hub tabs with roll notches.

2. Feed paper across table and under arm.

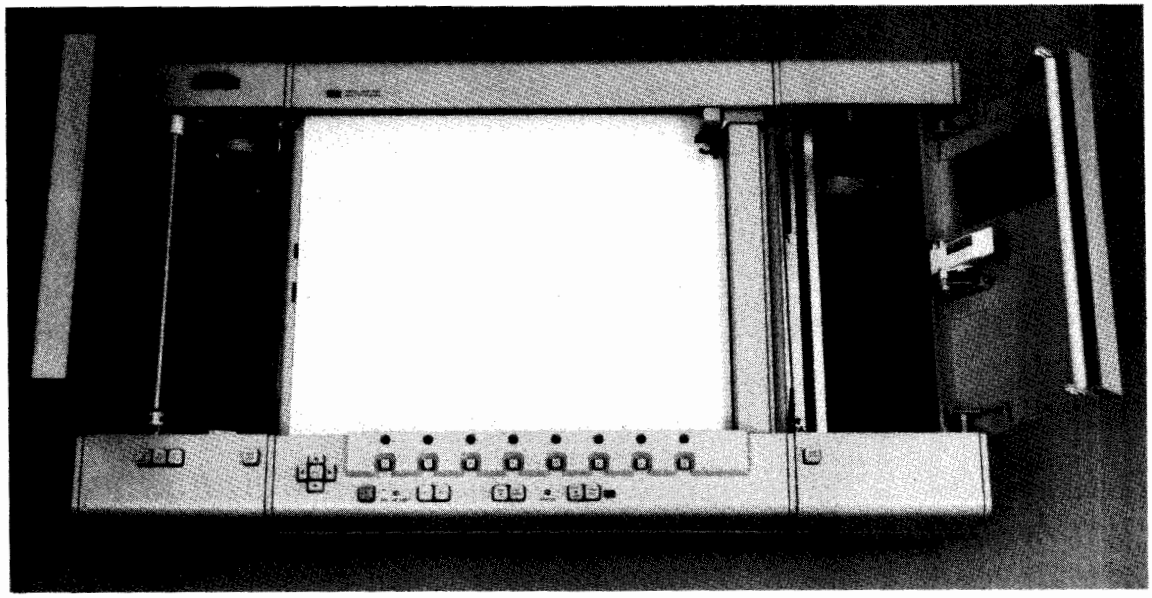
3. Engage paper sprocket holes and sprockets at each end of take-up roller. Hold paper on roller while closing door.

4. Close supply module door. Make sure paper is not on top of front edge guide.

5. Advance paper with thumb wheel until tensioned. Turn plotter on and advance paper at least once with front panel buttons.

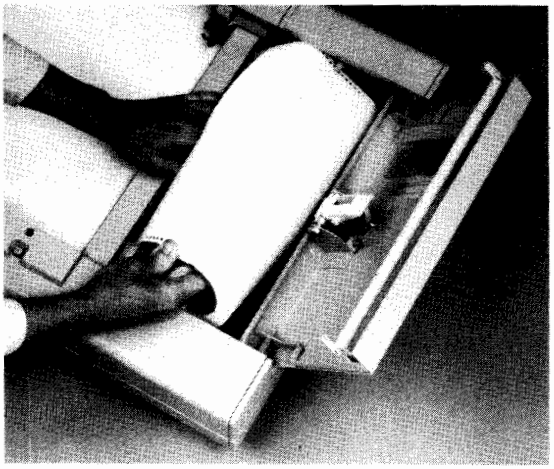
Successful loading of roll paper will turn the page advance option on. Electrostatic paper hold-down is disabled while roll paper is loaded.

Set the English/metric switch on the back of the paper take-up module to the desired position. Paper advance distances for both settings are specified under the AF and AH commands (Chapter 9).



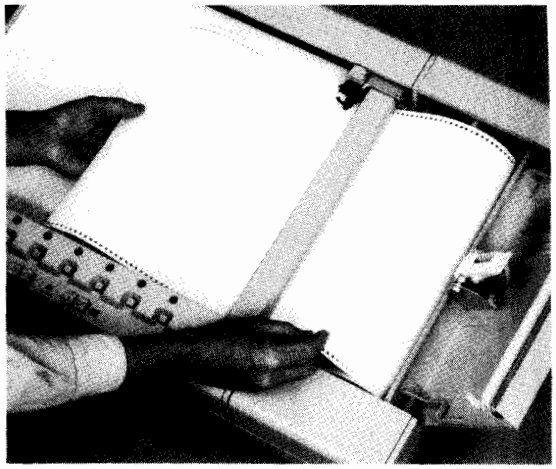
9872-A-167-1

Paper Modules Open



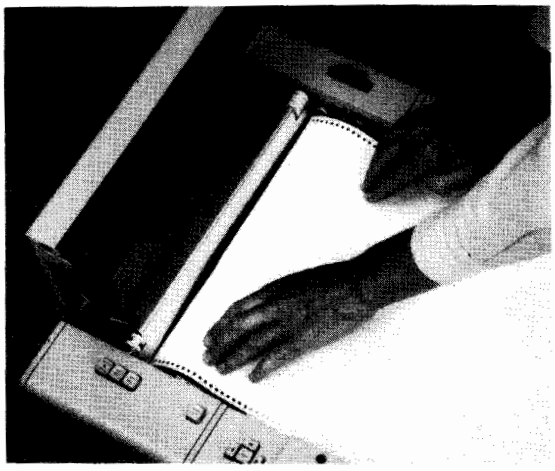
9872-A-168-1

Installing Paper Roll



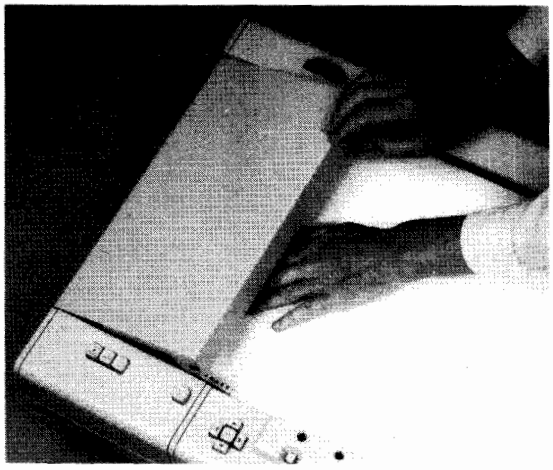
9872-A-169-1

Threading Paper Across Platen



9872-A-170-1

Engaging Paper on Sprockets



9872-A-171-1

Closing Take-up Module Door

Paper Loading 9872T

1

# The Confidence Test

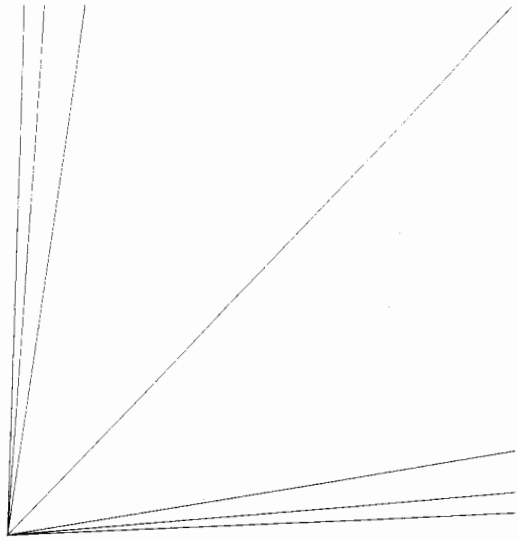
The confidence test verifies mechanical and electronic functions of the 9872 plotter and draws the following test plot. Perform the test in the following manner.

1. With the plotter turned off, disconnect all interface cables. Set listen only switch to zero. If a trace is desired, be sure a pen is mounted in the penholder on plotter arm.

2. Turn the plotter on by depressing line switch.

3. Move the confidence test switch on the rear panel to 1.

4. At the completion of the test plot, all lamps on front panel will be turned on and the pen will come to rest in the lower left corner of the platen. Now set the confidence test switch to 0. The pen will move to the lower right corner of the platen.



A plotter which does not complete the confidence test as illustrated above should be serviced. This plot has been reduced.

Chapter 2

# Plotter/Computer Communications



This chapter describes how your HP-IB compatible computer communicates with the HP 9872 plotter. Included are addressing the 9872, the function of listen-only mode, bus commands, addressing the 9872 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 9872 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.

---

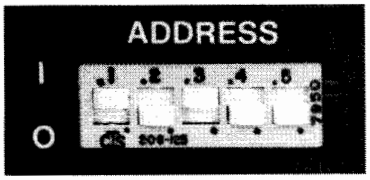
# The Plotter Address Code



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 through 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.




Plotter Address Switches

The following table lists the switch positions for each address value. Note switches are in reverse order on the back panel of the plotter.

2

## 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 9872C and HP 9872T graphics plotters are 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 1. 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. No responses to a serial poll are possible. However positive responses to a parallel poll can occur. The confidence test cannot be executed. When used with a plotter ROM in HP desktop computers, the listen-only switch must be set to 0.

Listen-only mode is included to facilitate use with less powerful controllers and multi-plotter systems. 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).

# Interface Messages

## Plotter Reaction to Bus Clear Commands DCL, SDC, and IFC



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

The 9872 plotter will react identically to the three commands DCL, SDC, and IFC sent over the HP-IB Bus.

The command will be received by the plotter when it looks for the next input. It will not be received while a plotter is internally occupied such as while drawing characters or dashed lines.

Once received, these commands will cause the plotter to complete plotting points in progress, stop, and reset itself to accept new input. However, if the computer continues sending data, the plotter will not appear to have stopped.

These commands are not intended to either stop a plot program or reinitialize the plotter.

## 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 Serial Poll

A serial poll enables the computer to learn the status or condition of devices on the bus. It is commonly used by the computer to determine who is requesting service.

The serial poll is so named because the computer polls devices one at a time rather than all at once. The plotter will respond to a serial poll by sending the status byte as described under the Output Status Instruction, OS (Chapter 3). The S-mask parameter of the Input Mask instruction, IM, is used to specify which status byte conditions will send the require service message. Unless the user changes the S-mask value from default setting of 0 the plotter will never give a positive response to a serial poll (see Input Mask, Chapter 3). Bit position 6 of the status byte will be set to 1 (if the S-mask value is not 0) when any of the conditions designated by the S-mask are true.

A computer must issue special commands to initiate and terminate a serial poll. During a serial poll, a device must be instructed to talk and the computer to listen. Therefore a serial poll cannot be executed when a plotter is in listen-only mode.

---

**NOTE**

Bit 6 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 6 is always 0.

---

**The Parallel Poll**

The plotter will respond positively to a parallel poll only if it has sent a require service message. The P-mask parameter of the Input Instruction, IM, is used to specify which status byte conditions will result in a logical 1 response to a parallel poll. The response to a parallel poll is limited to setting the appropriate data line to a logical 1. The line used is determined by the plotter's address value as shown in the table below:

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

Plotter Preset Address


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 which sets the ATN and EOI lines to 1. The computer 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.

It is important to remember that the 9872 will not send a logical 1 unless the P-mask bit value has been changed from the default value of 0 and some condition included in the new P-mask value is true. The plotter can respond positively to a parallel poll in listen-only mode.

# Addressing The 9872 As A Talker Or Listener



In order to communicate effectively with the 9872 plotter it is important that you completely understand the addressing protocol of your computer. Therefore, you may wish to review this aspect of your computer before proceeding.

## Computers With No High Level I/O Statements

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.

## Computers With High Level I/O Statements

In more powerful 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#, 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,''lbHP'',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$=''SENDING DATA''
30 B=85
40 Y=2000
50 PRINT ''PA1000,'',Y
60 PRINT ''LBHP'';B;A$;''␃''
70 END
```

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

Result: HP 85 SENDING DATA

HP 1000 Example

This example uses FORTRAN IV and assumes that the system has been configured so that the logic unit number 13 sends data to an HP-IB address of 1. Therefore, the plotter address switch on the back panel has been set to 1. The program name, VBP1, may be changed to any other legal program name and line numbers as given are only necessary for the format statements. The field width specification of 4 is adequate to plot to the location 1000,1000; you may wish to use a field width of 5 or 6 to allow for

pen positions up to the mechanical limits of the plotter. A six-character field would only be necessary for scaled negative data.

```
FTN4,L
      PROGRAM VBP1
10    IY=2000
20    IB=1000
30    WRITE (13,101) IY
40    WRITE (13,102) IB
101   FORMAT ("PA1000,",I4)
102   FORMAT ("LB HP ",I4," SENDING DATA  ")
      END
```

A terminator is sent by the HP1000 following WRITE statements.

Result: HP 1000 SENDING DATA

## Plotter-To-Computer

Outputting data from the plotter to the computer is typically accomplished using I/O statements such as READ, 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.

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 9872C if plotter is a 9872C or
1000 1000 0 9872T if plotter is a 9872T

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 | 9872C or |
| 1000 | 1000 | 0 | 9872T |

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 | 9872C or |
| 1000 | 1000 | 0 | 9872T |

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 | 9872C |
| or | |
| 1000 | 1000 |
| 0 | 9872T |

HP1000 Example

This example uses FORTRAN IV and assumes that the system has been configured so that the logic unit number 13 sends data to an HP-IB address of 1. Therefore, the plotter address switch on the back panel has been set to 1. The program name VBP2 may be changed to any other legal program name and the line numbers as given are only necessary for the format statements. A field width specification of 5 would be necessary to output pen positions where either the X or Y position was greater than 9999. Data is read in from the plotter using free field format so that the commas sent by the plotter between output parameters are interpreted as separators.



```
FTN4,L
      PROGRAM VBP2
      DIMENSION A(3)
10    WRITE (13,101)
101   FORMAT (''PA1000,1000;OC'')
20    READ (13,*) IX,IY,IP
102   FORMAT (3I5)
30    WRITE (13,103)
103   FORMAT (''OI'')
40    READ (13,104) A
104   FORMAT (3A2)
45    WRITE (1,102) IX,IY,IP
50    WRITE (1,104) A
      END
```

Displayed current pen position and identification.

```
 1000 1000    0
9872C
```

# 2

Chapter 3

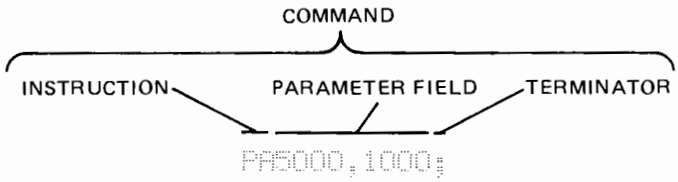
# General Programming Instructions



This chapter introduces the 9872 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 9872 Plotter Instruction Set

The instruction set for the 9872 consists of 43 Hewlett-Packard Graphic Language (HP-GL) instructions which fall into 7 basic groups. The 9872T has an eighth group of three additional HP-GL instructions for paper advance. A command is defined as an instruction followed by its parameter field and a terminator as shown in the following example:




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

1. Integer Format: Integers between −32768 and +32767 with scaling off and −16384 and +16383 with scaling on. No decimal point 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.

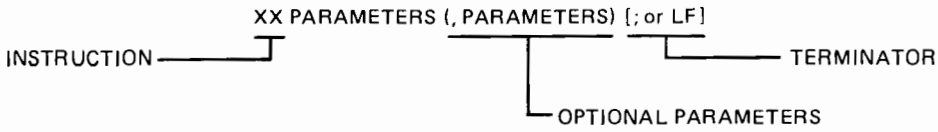
3. Label Fields: Any combination of text, numeric expressions, or string variables. Refer to the Label Instruction LB (Chapter 6) for a complete description.

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. The syntax used throughout this manual is [; or LF]. Some systems automatically send a line feed LF at the end of output statements; this LF will terminate a parameter field. On such systems the terminator [; or LF] may be omitted at the end of the last instruction in a line of computer output. (See examples under Sending and Receiving Data Chapter 2.)



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

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




**NOTE**

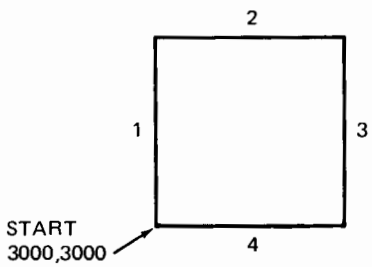
The parentheses used to show optional parameters are not used when writing programs. The optional parameters are separated (delimited) using only the comma.

Consider the following example of some typical instructions, parameter fields, and terminators. Sending the following two lines causes the square shown below to be drawn. The lines are numbered in the order they are drawn.

LINE 1. SP3;PU;PA3000,3000;PD;

LINE 2. PR0,1000,1000,0,0,-1000,-1000,0;SP0;

1 2 3 4



Line 1 selects pen 3 (SP3), raises the pen (PU), causes the plotter to move to the absolute position X = 3000, Y = 3000 (PA) and then lowers the pen (PD).

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, etc. until it has drawn a square of 1000 plotter unit sides. The pen is then raised (PU) and returned to the stall (SP0).



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. Refer to Chapter 2, Sending and Receiving Data, for examples of addressing protocol and I/O command statements used on a variety of computers.

---

**NOTE**

Some BASIC (Beginners All-purpose Symbolic Instruction Code) statements are included in examples as necessary to key the user to one possible program solution. 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 9872 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 $\theta$ | Absolute character slant (from vertical) |
| SR width, height | Relative character size |
| SS | Select standard character set |
| UC (pen,)x,y,pen(,x,y)(,....) | User defined character |
| **LINE TYPE GROUP** | |
| LT t(,l) | Designate line type and length |
| SM c(,n) | Symbol mode c at $n^{th}$ coordinate |
| SP | Select pen |
| VA | Adaptive velocity |
| VN | Normal velocity |
| VS v(,n) | Select velocity v for pen n |
| **DIGITIZE GROUP** | |
| DC | Digitize clear |
| DP | Digitize point |
| 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** | |
| AP | Automatic pen pickup |
| DF | Set default values |
| IM e(,s(,p)) | Input e, s, and p masks |
| IN | Initialize |
| OA | Output actual position and pen status |
| OC | Output commanded position & pen status |
| OE | Output error |
| OF | Output factors |
| OI | Output identification |
| OO | Output options |
| OS | Output status |
| **PAPER ADVANCE GROUP** | |
| AF or PG or PG1 | Advance full page |
| AH | Advance half page |
| EC | Enable cutter |

# The Default Instruction DF

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

Syntax:

DF [; or LF]



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

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

Default Conditions

| Function | Conditions |
|---|---|
| Relative character direction | Horizontal (DR1,0) |
| Line type | Solid line |
| Line pattern length | 4% of the distance from P1 to P2 |
| Input window | Mechanical limits of plotter 0,0,16000,11400 |
| Relative character size | Width = 0.75% of $\lvert P2_X - P1_X \rvert$,<br>Height = 1.5% of $\lvert P2_Y - P1_Y \rvert$ |
| Automatic pen pickup | on |
| Pen velocity | 36 cm/s |
| Adaptive pen velocity | off |
| Symbol mode | off |
| Tick length | tp = tn = 0.5% of $\lvert P2_X - P1_X \rvert$ for Y tick and<br>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 |
| Scaling | off |

In addition, P1 and P2 are not changed and the current pen location is not changed. The state of the cutter and the status of the paper check bit are not changed on the 9872T.

# 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 or initializing it from the front panel. The initialize command sets the plotter to the same conditions as the default command and sets these additional conditions.

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

The scaling points P1 and P2 are set to the points P1 = (520, 380) and P2 = (15720, 10380) on the 9872C or the 9872T with sheet paper loaded. For the 9872T with roll paper loaded the settings are P1 = (520, 1020), P2 = (15760, 11180) in English mode and P1 = (520, 1140), P2 = (15720, 11140) in metric mode.

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

The cutter is enabled and the paper check bit is set to 1 on the 9872T.

# The Input Mask Instruction IM

The input mask instruction IM specifies the conditions under which an error message, require service message, and positive parallel poll response will occur.

Syntax:

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



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

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

For example the default E-mask value 223 (1 + 2 + 4 + 8 + 16 + 64 + 128) will specify that all error numbers except 6 can set the error bit in the status byte and turn on the error light whenever they occur. Error 6, however, will not set the error bit or turn on the error light if it occurs since it is not included in the E-mask value. Note an E-mask value of 159 would result in identical plotter behavior since error 7 is not used on the 9872 plotter.

The S-mask value specifies the status-byte conditions that can send the require service message by setting interface line SRQ on the bus 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 | Meaning |
|---|---|---|
| 1 | 0 | Pen down |
| 2 | 1 | P1 or P2 changed; cleared on "OP" |
| 4 | 2 | Digitized point available; cleared on "OD" |
| 8 | 3 | Initialized; cleared on "OS" |
| 16 | 4 | Ready for data |
| 32 | 5 | Error; cleared on "OS" |
| | 6 | Require service sent (SRQ) |
| | 7 | Not used |

Only combinations of the first 6 bits (called bit 0 to bit 5) can be specified to send the require service message. Bit 6 is used to specify whether or not the plotter has sent the require service message and bit 7 is not used (always set to logical 0).

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

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

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

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

The plotter, when 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 require service message) and the P-mask to 0 (none of the status-byte bits can cause a parallel poll response of logical 1).

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

# The Output Error Instruction OE

The output error instruction OE makes the decimal equivalent of the last error (if any) available for output to the computer.

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 and makes it available for output 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 | Bad parameter |
| 4 | Illegal characters |
| 5 | Unknown character set |
| 6 | Position overflow |
| 7 | Not used |
| 8 | Out of roll paper |

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 Factors Instruction OF

The output factors instruction OF instructs the plotter to make the number of plotter units per millimetre in each axis available for output.

Syntax:

OF [; or LF]

3

OF

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

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

The 9872 will always output two positive ASCII integers in the form:

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 on the 9872 plotter.

# The Output Identification Instruction OI

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

When the plotter is instructed to talk and the computer to listen, the 9872C always returns:

9872C CR LF

and the 9872T returns:

9872T 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.

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

The plotter will always respond to the instruction with a message consisting of eight ASCII integers in the form:

C, 1, 0, 0, 0, 0, 0, 0 CR LF

where C is as described below, 1 means the plotter has pen select capability and the last six numbers are always zero on the 9872. C takes on a value 0–3 as follows:

| C | Paper Check Bit | Advance Option |
|---|---|---|
| 0 | clear (0) | off (0) |
| 1 | clear (0) | on (1) |
| 2 | set (1) | off (0) |
| 3 | set (1) | on (1) |

A 9872C will always output a value of C = 2.

On a 9872T, the advance option is set if the roll paper is present and properly installed. The paper check bit is set at power up or initialization, and anytime the pen is put down under either program or front panel control. It is also set anytime the out of paper switch indicates no paper before or after a paper advance or attempt to advance. The paper check bit is cleared to zero after any successful advance. This instruction can be used on the 9872T to ascertain whether the plotter is loaded with roll paper and the plot area is clear; if this is true, C = 1. The OO instruction should be sent before an IN instruction since the IN instruction will set the paper check bit to 1 and paper may be wasted.

# 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 change or change attempted |
| 4 | 2 | Digitized point available |
| 8 | 3 | Initialized |
| 16 | 4 | Ready for data |
| 32 | 5 | Error |
| 64 | 6 | Require service message set |
| 128 | 7 | Not used (always set to 0) |

Upon power up, the status is decimal 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.

# 3

# Chapter 4
# Scaling



This chapter describes the plotting area, plotter and user units, and the instructions that enable you to scale the plotting area into user units. Procedures for setting the scaling points manually and programmatically are described. The following instructions are included in this chapter:

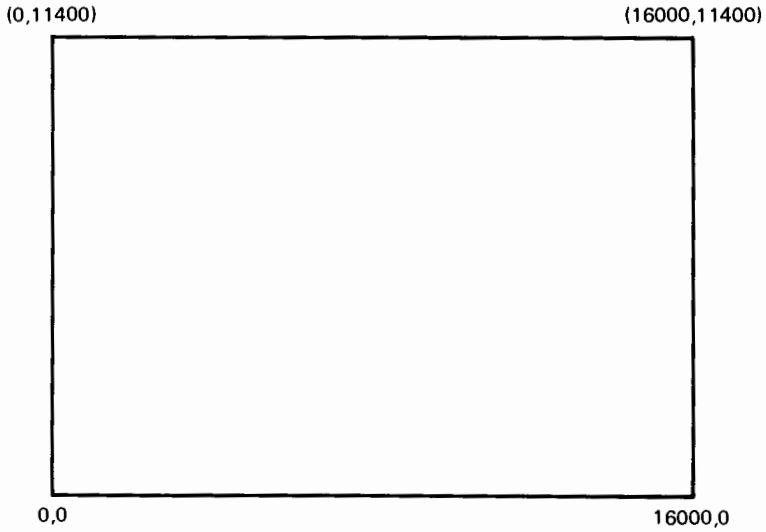
Input P1 and P2 (IP)
Output P1 and P2 (OP)
Scale (SC).

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

## The Plotting Area

The absolute plotting area is established by the mechanical limits of pen motion while the pen is down. This plotting area is part of the platen area, the platen being the white flat surface area of the plotter. The physical size of the plotting area on the platen is 285 × 400 mm (11.2 × 15.75 in.). The plotting area is divided into plotter units where one plotter unit = 0.025 mm.

The absolute plotting area is shown below.



When the plotter is initialized by power-up, front panel controls, or use of the IN instruction, scaling points P1 and P2 are set, as shown in the following table.

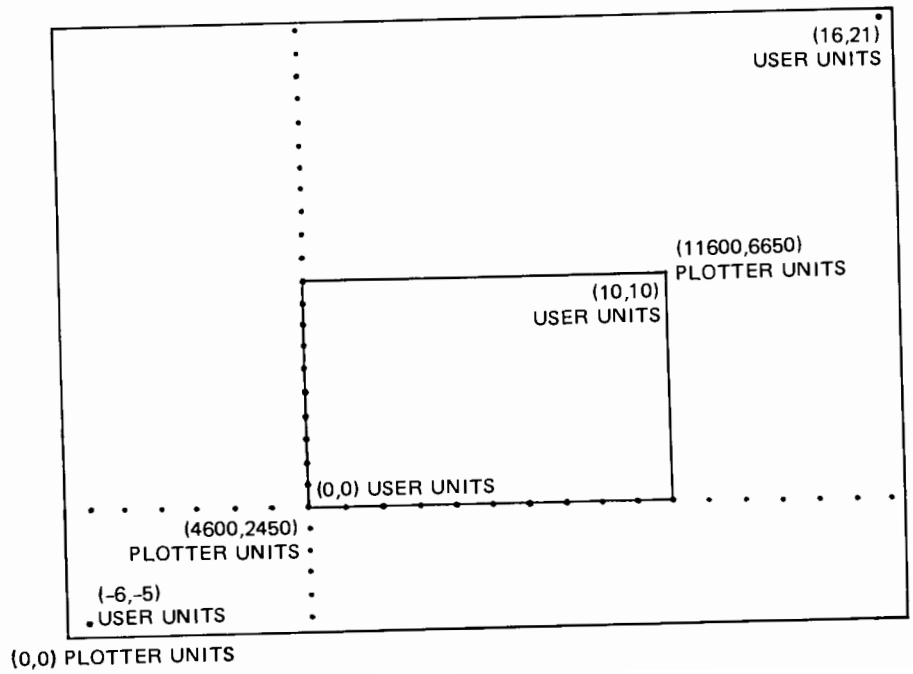
| Plotter | $P1_X,P1_Y$ | $P2_X,P2_Y$ |
|---|---|---|
| 9872C or 9872T, no paper or sheet paper | 520,380 | 15720,10380 |
| 9872T, roll paper loaded, paper switch set to metric | 520,1140 | 15720,11140 |
| 9872T, roll paper loaded, paper switch set to English | 520,1020 | 15760,11180 |

## User Units



The size of a user unit is determined by the parameters of the Scale instruction (SC) and the setting of the scaling points, P1 and P2. The scaling point P1 is assigned the value Xmin, Ymin, while the scaling point P2 is assigned the value Xmax, Ymax. 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 "faraway" areas described under the PA command in Chapter 5) is scaled into units of this size. Thus, if P1 is not 0,0 plotter units, and/or P2 is not 16000,11400 it is possible to physically plot to a point outside the rectangle defined by P1 and P2.

In the following illustration, the scaling points are set to 4600,2450 and 11600,6650. Assigning a value to 0,0 to P1 and 10,10 to P2, the platen is divided into user units as shown below. The minimum value that can be plotted on the platen surface is −6,−5 and the maximum value is 16,21. Notice that a user unit is not necessarily the same size on the X axis as it is on the Y axis and that the scaled area extends beyond the rectangle established by P1 and P2.



## Setting the Scaling Points Using Front Panel Controls

Scaling points may be set using front panel controls [ENTER •] [P1] and [ENTER •] [P2]. When the plotter is turned on, default scaling points are set as described earlier in this chapter.

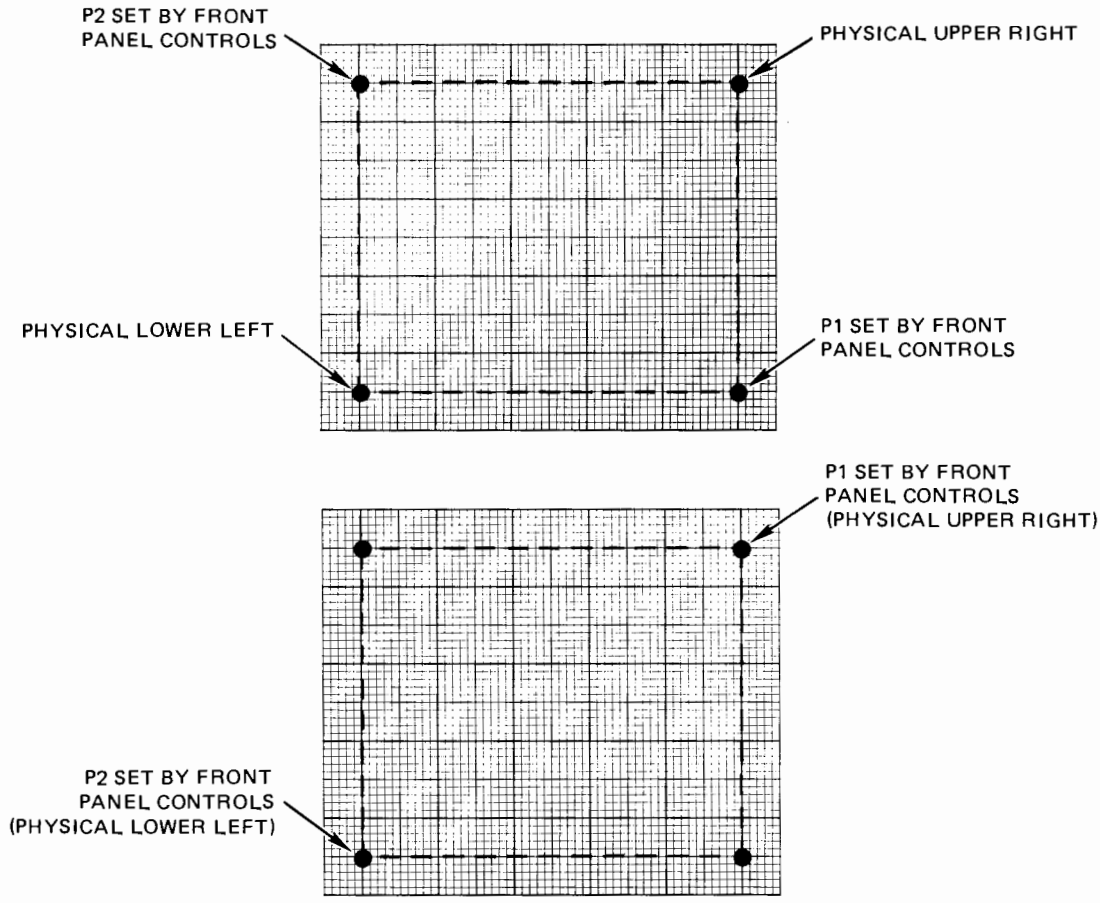
Scaling points can be relocated using plotter front panel controls as follows:

Position the pen at the new location using [▲] [◀] [FAST] [▶] [▼].

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



P1 and P2 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 as described in the next section.

# 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, must be in absolute plotter units, and also within platen maximum range X = 0,16000, Y = 0,11400.



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 shown in the following table:

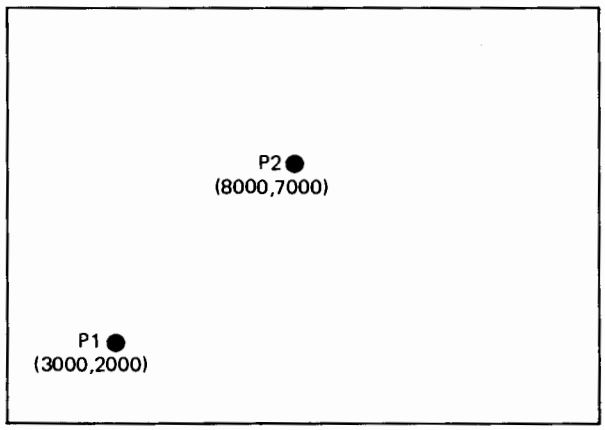
| Plotter | $P1_X$,$P1_Y$ | $P2_X$,$P2_Y$ |
|---|---|---|
| 9872C or 9872T, no paper or sheet paper | 520,380 | 15720,10380 |
| 9872T, roll paper loaded, paper switch set to metric | 520,1140 | 15720,11140 |
| 9872T, roll paper loaded, paper switch set to English | 520,1020 | 15760,11180 |

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

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

Send: $P1_X$ $P1_Y$ $P2_X$ $P2_Y$

LINE 1: IP3000,2000,8000,7000;



# 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 to the computer.

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 Scale Instruction SC

The scale instruction SC assigns user unit values to scaling points P1 and 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.

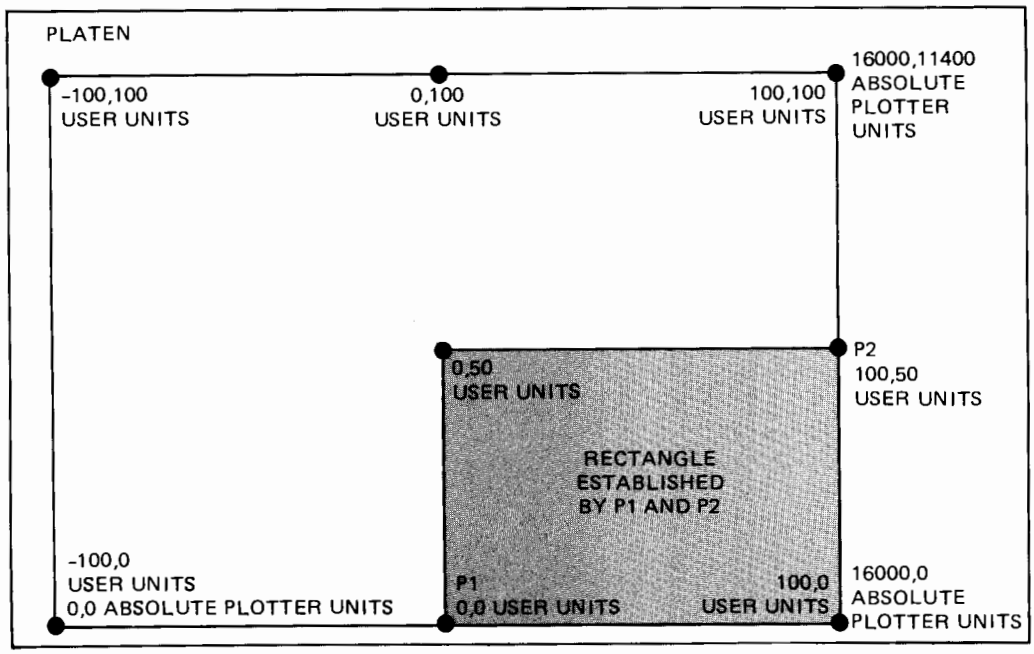
4

SC

When parameters are used, all four parameters are required and must be integers between −16383 and +16383. Xmax must be greater than Xmin and Ymax greater than Ymin. The Xmin,Ymin values are assigned to the scaling point P1 and the Xmax,Ymax values are assigned to the scaling point P2. 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. IP8000,0,16000,5710;
LINE 2. SC0,100,0,50;

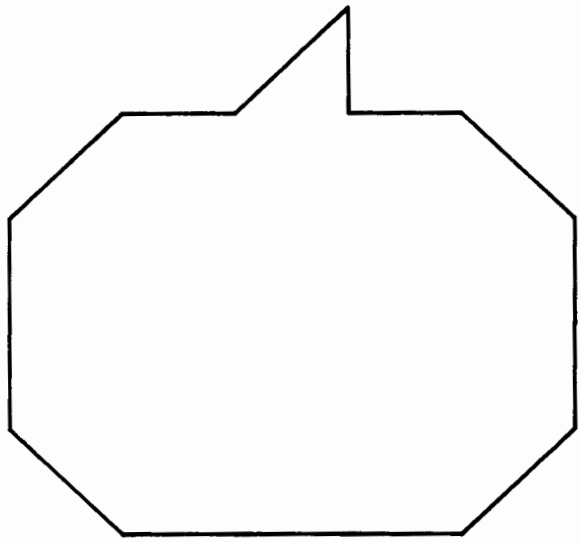


Let us now assume we have scaled an area of the platen into 25 × 18 user units. With integer scaling, plotting is only possible to coordinates with integer values. It is only possible to plot to a finite number of points on the platen, in the current example 26 × 19 (X-coordinates 0 to 25, Y-coordinates 0 to 18). 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 9 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 18 does not allow plotting to enough points, and results in a circle of poor resolution.




```
  LINE 1. IN;SC0,25,0,18;SP1;
■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)+9
★LINE 5. PA X,Y;PD;
■LINE 6. NEXT T
  LINE 7. SP0;
```



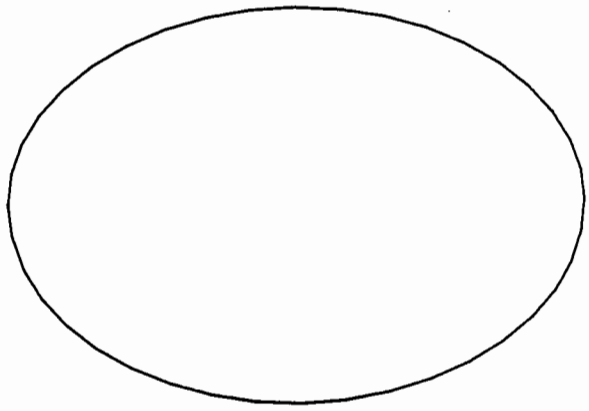
■BASIC Statement. Do not send to plotter.

★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

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,16000,0,16000;SP1;
■LINE 2. FOR T=0 TO 2*PI STEP PI/20
■LINE 3. X=2.5*1000*COS(T)+8000
■LINE 4. Y=2.5*1000*SIN(T)+8000
★LINE 5. PA X,Y;PD;
■LINE 6. NEXT T
  LINE 7. SPO;
```





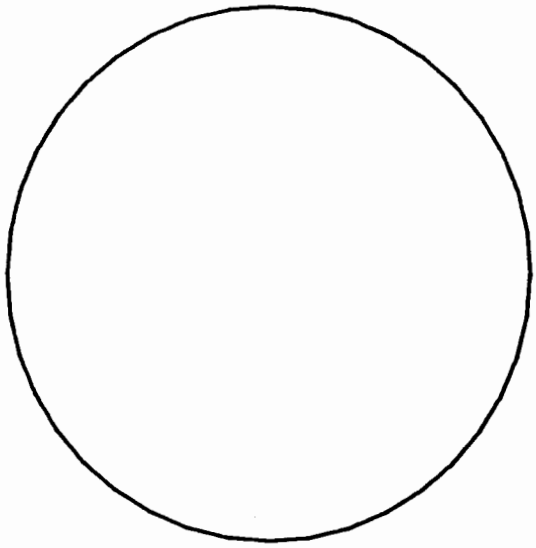
Notice that the plot is not a perfect circle. This is a result of the aspect ratio of the plotter ($|P1_X - P2_Y| \neq |P1_Y - P2_Y|$) and the parameters of the SC command. In the preceding example, which has been slightly reduced, P1 and P2 were the default values for a 9872C or a 9872T without roll paper.

■BASIC statement. Do not send to plotter.

★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

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.

```
  LINE 1. IN;IP1000,1000,10000,10000;SP1;
  LINE 2. SC0,16000,0,16000;
■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. SP0;
```



We now plot a perfect circle

■BASIC statement. Do not send to plotter.

★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

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

```
LINE 1. IN;IP520,1140,15720,11140;SP1;
LINE 2. SC0,1520,0,1000
■LINE 3. FOR T=0 TO 2*PI STEP PI/20
■LINE 4. X=100*COS(T)+760
■LINE 5. Y=100*SIN(T)+500
★LINE 6. PA X,Y;PD
■LINE 7. NEXT T
LINE 8. SP0;
```

Line 1 sets P1 and P2.
Line 2 — 1 scaled unit = 10 plotter units.

Offsets 760 and 500 in lines 4 and 5 center circle in plotting area.

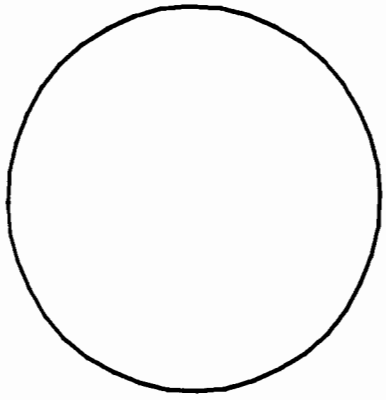
If the scale command sets an equal number of user units in the X- and Y-axes, the X or Y value must be adjusted to correspond with the aspect ratio when the plotting area is not square. Both programs plot the same circle, but the pen used is different.

Program 2

```
LINE 1. IN;IP520,1140,15720,11140;SP2;
LINE 2. SC0,1000,0,1000;
■LINE 3. FOR T=0 TO 2*PI STEP PI/20
■LINE 4. X=65.78947*COS(T)+500
■LINE 5. Y=100*SIN(T)+500
★LINE 6. PA X,Y;PD;
■LINE 7. NEXT T
LINE 8. SP0;
```

Line 1 sets default P1 and P2 so
$|P1_X - P2_X| = 15200$
$|P1_Y - P2_Y| = 10000$

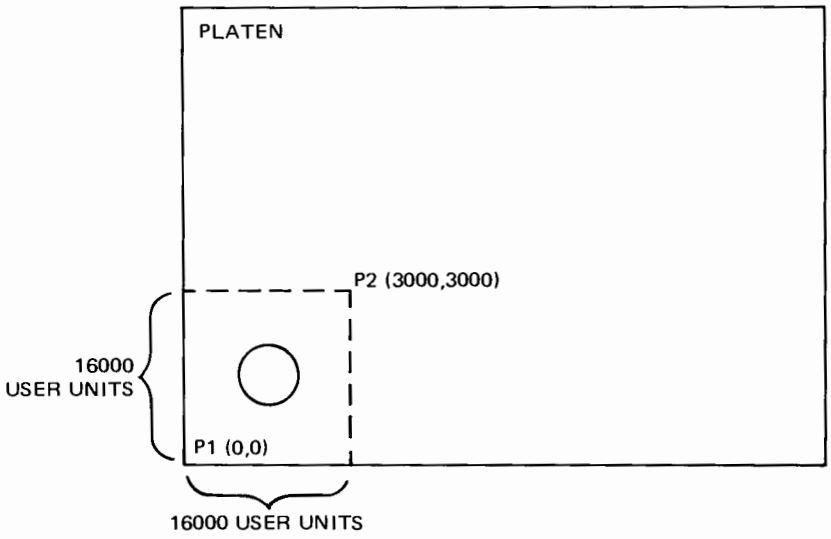
$10000/15200 = 65.78947/100$



■BASIC statement. Do not send to plotter.
★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

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;SP1;
  LINE 2. SC0,16000,0,16000;
■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. SP0;
```






■BASIC statement. Do not send to plotter.

★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

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, or to enable use of user units beyond the limits ±16384. This method of scaling is covered in Appendix B of this manual.

# Chapter 5
# Pen Control and Plotting

This chapter describes the instructions that enable you to perform all plotting movements and control the pen. Plotting moves can be made to an absolute set of coordinates, or relative to the given pen position. The absolute coordinates or relative movements are in absolute plotter units if scaling is off or user units if scaling is on. Any of eight pens can be chosen. The pen can be raised or lowered before or after a move. Its velocity can be controlled.



## The Pen Select Instruction SP

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


Syntax:

SP pen position number [; or LF]

The pen position number must be an integer in the range of 0 through 8. When the command SP is executed, the pen arm raises the pen it is currently holding (if any) and returns it to the position from which it was originally fetched. The new pen designated by the SP command is then fetched and the pen arm returns to its last position prior to the SP command.

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

A pen position number of 0 or no parameter directs the pen arm to return the pen it is currently holding to its stall. Then the pen arm returns to its last position prior to the SP command and assumes its prior pen up/pen down status.

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

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

## The 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 Automatic Pen Pickup Instruction AP

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

Syntax:

AP (integer) [; or LF]

An AP command with no parameters (AP;) enables automatic pen pickup. Pickup enabled is the default condition.

An AP command with a valid integer parameter disables automatic pen pickup. Using AP0 is recommended.

An AP command with invalid parameters has no effect on pickup.

The programmed pen status (up or down) does not change when the pen is lifted at the end of 65 seconds. Executing an OC or OA instruction will return the programmed pen status.

# The Velocity Select Instruction VS

The velocity select instruction VS specifies the pen speed, in centimetres per second, for plotting and lettering operations.

Syntax:

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

The pen velocity parameter can be any integer between 1 and 36 and represents pen down speed in cm/s. If the optional pen number (an integer, 1 to 8) is specified, the speed will apply only to that pen. If a pen number is not specified, the speed applies to all pens. A VS command has no effect on pen speed while the pen is raised.

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

A VS command with invalid parameters turns on the error light and pen velocity does not change.

A VS command remains in effect until another valid VS command is executed or the plotter is reinitialized or set to default conditions.

## The Adaptive Pen Velocity Instruction VA

The adaptive pen velocity instruction VA provides the means to adapt the pen-down speed automatically to approximate the rate at which the computer sends coordinate data to the plotter.

Syntax:

VA [; or LF]

No parameters are used. However, the terminator ; or LF must be included to complete the command. A VA command with parameters turns on the error light but does not alter the velocity mode. A VA command remains in effect until a VN is executed or the plotter is initialized or set to default values. This mode provides a smoother plot than the normal velocity mode when plotting coordinates are generated by a relatively slow program routine (fewer than 15 coordinates/s). The maximum pen speed will not exceed the speed selected by the previous VS command.



If the time required to complete a plot is a consideration, care should be taken when including the VA command in a program, since the VA command slows the plotter down to the controller data rate. If the data creates long vectors, plotter movement will be very slow and should the data rate increase, it will take a few data points and a significant period of time before the plotter is again up to data speed.

## The Normal Velocity Instruction VN

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

Syntax:

VN [; or LF]

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

After receipt of a VN command, the pen returns to the velocity specified by the previous VS command or default velocity if no VS command has been executed.

A VN command with parameters will turn on the error light and adaptive velocity mode will not be cancelled.

# The Plot Absolute Instruction PA

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

Syntax:

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

A PA command requires that both the X- and Y-coordinates be specified (coordinate pair). The X-coordinate parameter specifies the absolute X location to which the pen will move in either plotter or user units. The Y-coordinate parameter specifies the absolute Y location to which the pen will move in either plotter or user units. If scaling is on, the coordinates are in user units. If scaling is off, the coordinates are in absolute 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.

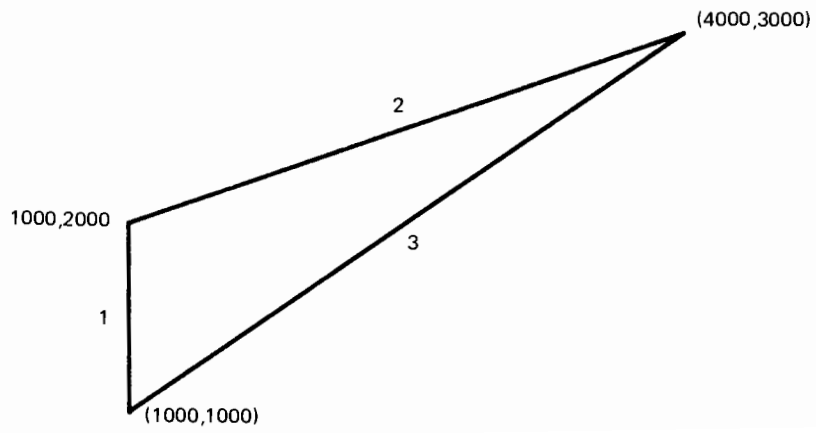
Using the PU or PD instructions, a pen control command can be placed before or after the PA command, raising (PU) or lowering (PD) the pen. If no pen control command is specified, the pen will assume the pen state (pen up or pen down) of the previous statement.

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 program causes the plotter to select pen 1 and draw a triangle. The lines have been numbered in the order in which they were drawn.

Send:

```
LINE 1. SP1;PA1000,1000;PD;
LINE 2. PA1000,2000,4000,3000,1000,1000;SP0;
```

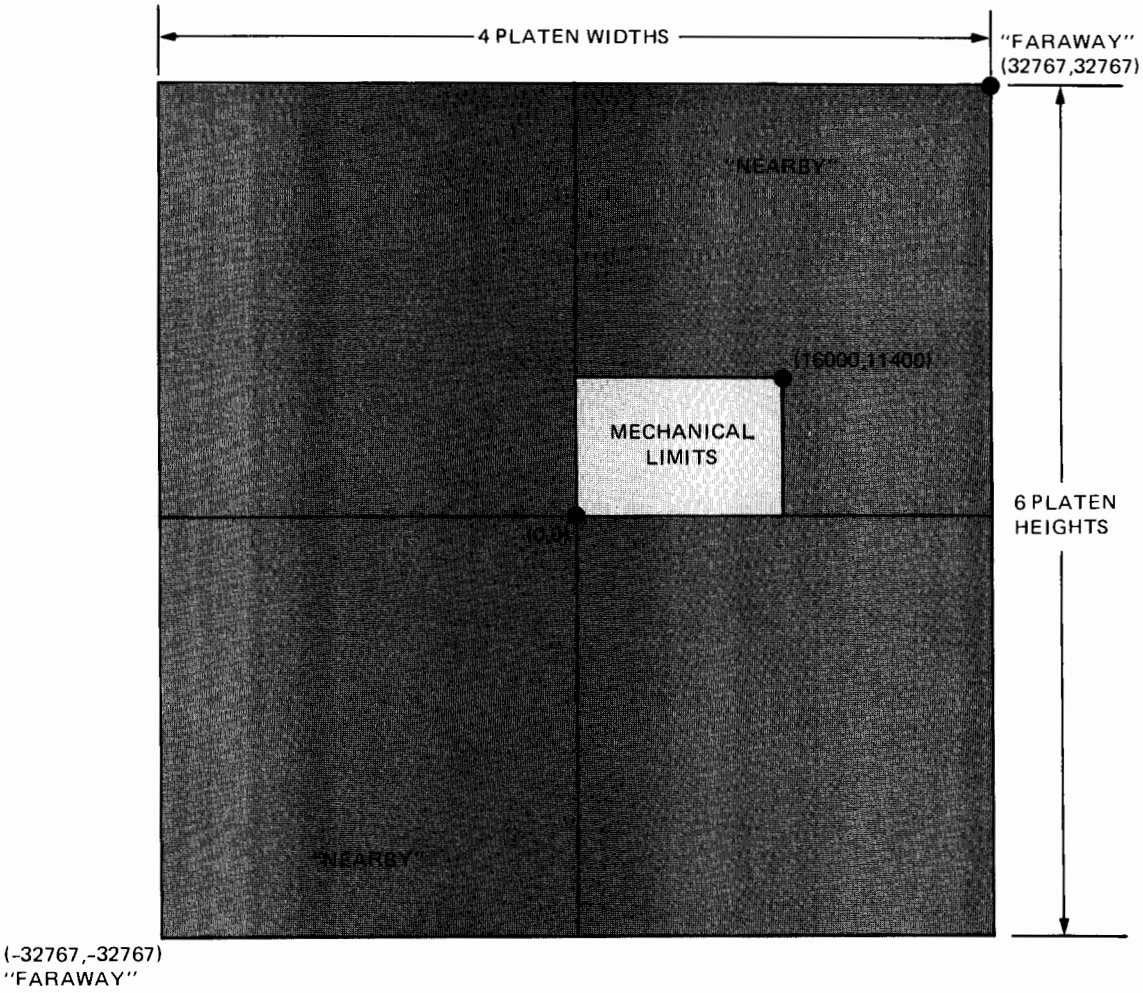


If the point specified by a PA command lies outside the current window (default window is the mechanical limits) but within the "nearby" area (see following illustrations), a line is drawn to the window limit and then the pen is raised. The pen remains raised until a point within the current window is specified. The OUT OF LIMIT light will turn on steady.

If the point specified by a PA command lies outside the window in the "faraway" area, the pen is raised and does not move from its last position. The OUT OF LIMIT lamp will blink. The pen remains raised until it moves from a point inside the window which was reached either using a valid PA command or using front panel controls.

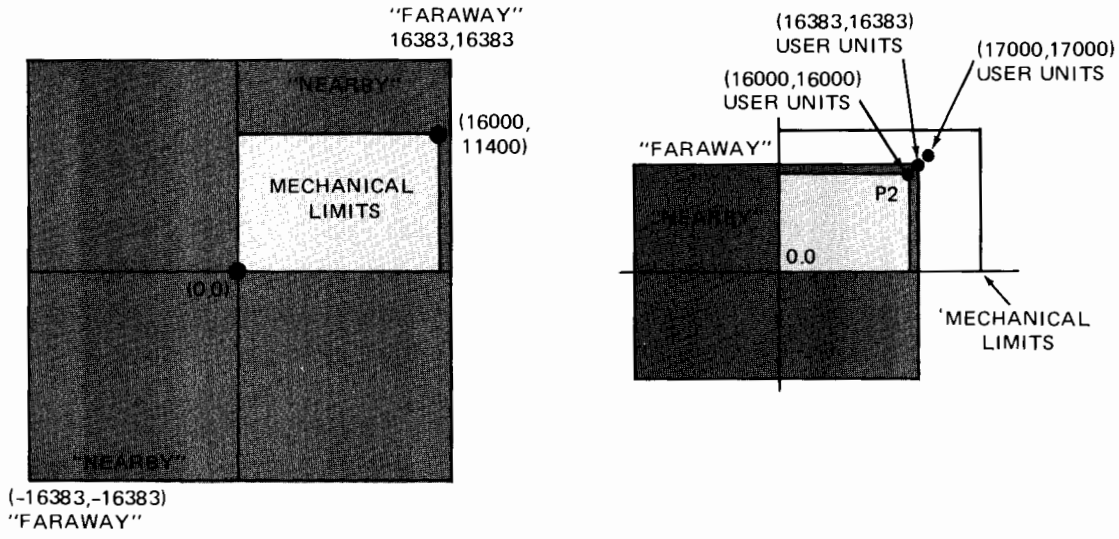
"Nearby" and "faraway" areas when scaling is off are shown below. The numbers are plotter units. The default window (mechanical limits) is lightly shaded. The "nearby" area is darker and the faraway area is the white area beyond the shading.






Scaling Off

When scaling is on, nearby and faraway areas change considerably as can be seen in the following diagrams. When scaling is on, a point is "faraway" if any parameter is less than −16383 or greater than +16383 or if its plotter unit equivalent is not between −16383 and +16383. The plotter unit equivalent = (parameter in user units) × (number of plotter units per user unit).




Scaling On

The left-hand diagram represents the maximum "nearby" area when scaling is on and, in that diagram, you are limited by the plotter unit equivalents being beyond the acceptable range. Consider, however, the right-hand diagram where P2 is set to some point in the center of the platen area. Now if scaling is set at 0 to 16000 on both X- and Y-axes, you will be in the "faraway" area if you plot the point 17000,17000 yet that would lie within the mechanical limits.

"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 window 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. When scaling is on, in-range coordinates must have both X-and Y-parameters between ±16383 and, when converted to plotter units, must also be between ±16383. 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 provides the means to move the pen, relative to its current location, the number of plotter or user units specified by the X- and Y-parameters that complete the command. Parameters are in plotter units with scaling off and user units with scaling on.

Syntax:

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

A PR command requires that both the X- and the Y-coordinates be specified (coordinate pair). 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.



The sign of the increment parameters determines the relative direction that the pen moves; a positive value moves the pen in a position direction and a negative value moves the pen in a negative direction.

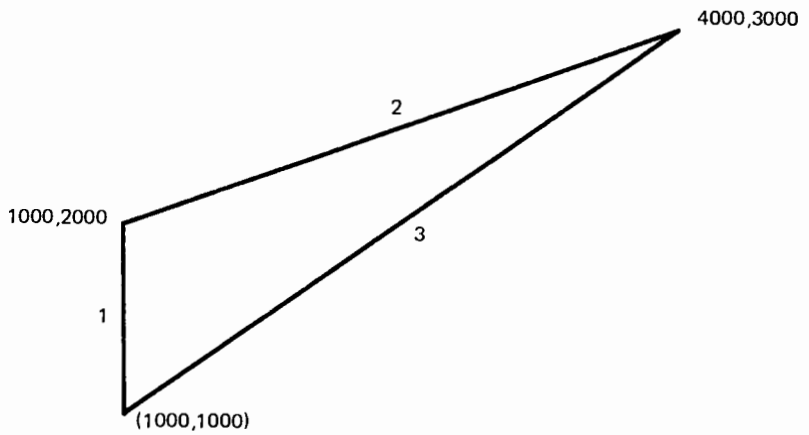
Any number of coordinate pairs separated by commas can be listed after the PR instruction. The pen will move relative to the previous point in the order given.

Using the PD or PU commands, a pen control command can be placed before or after the PR command, raising (PU) or lowering (PD) the pen. If no pen control command is specified, the pen will assume the pen state (pen up or pen down) of the previous statement. Plotting is done only within the currently defined window area of the platen.

The following program which uses PR instructions causes the plotter to draw a triangle identical to the one previously drawn using the PA instruction only.

Send:

```
LINE 1. IN;SP1;PA1000,1000;PD;PR0,1000;
LINE 2. PR3000,1000,-3000,-2000;SP0;
```



In-range coordinates with scaling off are defined as:

1. both X- and Y-parameters being integer plotter units having values between ±32767.

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.

In-range coordinates with scaling on are defined as:

1. both X- and Y-parameters being integer user units having values between ±16383.

2. each succeeding X- and Y-increment, when added to the current X- and Y-coordinate, is not less than −16383 or greater than +16383 user units, and when converted to plotter units does not exceed ±16383 plotter units when referenced from 0,0.



If a PR command specifies a point outside the window in the "nearby" area as described under the PA instruction the pen draws a line to the limit of the window 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 window area.

# 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. IP0,0,7544,7544;SP1;
  LINE 2. SC0,1000,0,1000;
■LINE 3. FOR T=0 TO 2*PI STEP PI/20
■LINE 4. X=INT(150*COS(T)+5000)
■LINE 5. Y=INT(150*SIN(T)+3000)
★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. The necessary comma enclosed in quotes is included here to delineate the variables X and Y.

■BASIC statement. Do not send to plotter.

★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

# 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, direction, and positioning of labels, as well as the instruction which enables you to design your own characters or symbols.

## Plotter Character Sets

The plotter has the capability of lettering with any of five internal character sets. Each of the character sets has identical alphabetic characters, but the symbols available vary from set to set. 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 [\] ^ _`
abcdefghijklmnopqrrstuvwxyz {| } ~
```

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 0 Standard ASCII | Set 1 9825 ASCII | Set 2 French/German ASCII | Set 3 Scandinavian ASCII | Set 4 Spanish/Latin American ASCII |
|---|---|---|---|---|---|
| 35 | # | # | £ | £ | ¿ |
| 39 | ' | ' | ´ | ' | ´ |
| 91 | [ | [ | [ | Ø | [ |
| 92 | \ | √ | 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 through 4) as the standard character set.

Syntax:

CS character set number [; or LF]

The character set number must be an integer in the range 0 through 4. 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 CS command 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 through 4) as the alternate character set.

Syntax:

CA character set number [; or LF]

The character set number must be an integer in the range 0 through 4. The character set designated is used for all labeling and lettering operations when the alternate character set is selected. Character set 0 is automatically specified as the alternate character set whenever the plotter is initialized.

A CA command 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 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. An 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 following program using CS, CA, and SS commands writes in 2 character sets where the character "_" is printed with and without backspace.

Send:

LINE 1. CSO;CA4;SS;LBS_E_T_O$_{5}$S_E_T_4$_{E}$

S_E_T_OSET4

# 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, decimal 3, 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 specified in a label command by enclosing it in quotes. Here is an example of text in a label command.



Send:

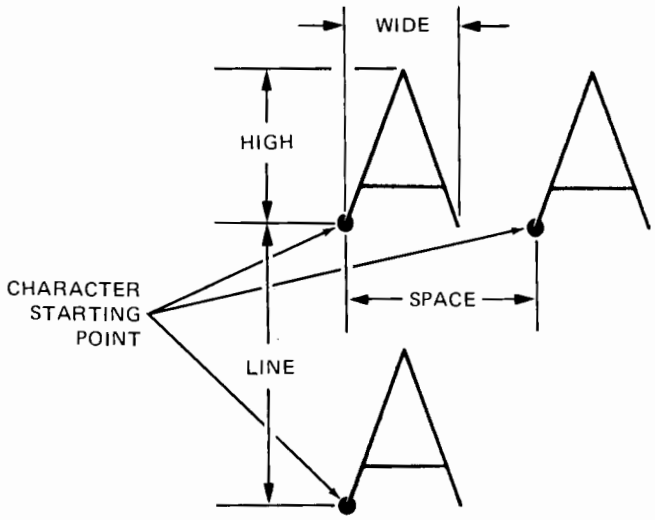
```
LBI AM A 9872 PLOTTER
```

Result:

I AM A 9872 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 in the following diagram. For a further explanation of character spacing, refer to Spacing Between Characters and the Character Grid, Chapter 6.

The diagram below illustrates character spacing, width, and height.




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.

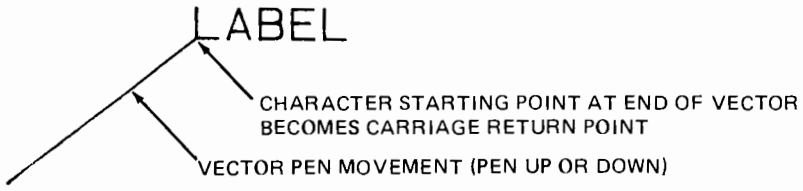
The character set used is designated by the commands CA and/or CS, and then selected by the commands SA or SS, the ASCII control characters shift-in or shift-out, or the default (standard set). If not specified, the default character set is set 0.

6

LB

When the plotter receives a carriage return character while in label mode, it returns to a defined carriage return point determined as follows:

**Vector Group Instruction or Direction Controls —** all labeling performed after a vector instruction or after pen movement by the direction controls 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 following the DI or DR command as the carriage return reference point unless otherwise changed.

## 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 on 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 is used as a delimiter between variables or literals 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 in order to establish fixed spacing between label strings. For close spacing of the label strings, the blank spaces can normally be suppressed by using a semicolon as the delimiter between variables or literals.

The following example illustrates the use of the comma as a delimiter when using variables for labeling. HP-GL mnemonics, literals, and terminators are enclosed in quotation marks.

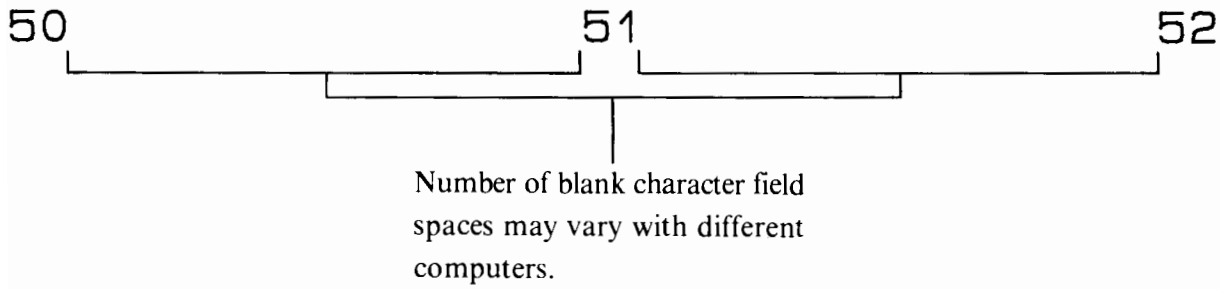


Send:

■LINE 1. X=50
LINE 2. ""LB"",X,X+1,X+2,""ε,""

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:




■BASIC statement. Do not send to plotter.

The following example illustrates use of the semicolon as a delimiter when using variables for labeling:

Send:

```
■LINE 1. X=50
  LINE 2. ""LB"";X;X+1;X+2;""E""
```

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.

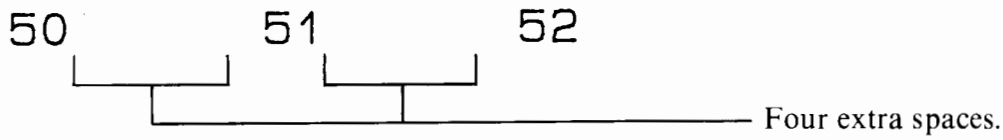
6

Send:

```
■LINE 1. X=50
  LINE 2. ""LB"";X;""    "";X+1;""    "";X+2;""E""
```

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

Result:




■BASIC statement. Do not send to plotter.

# The Absolute Direction Instruction DI

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

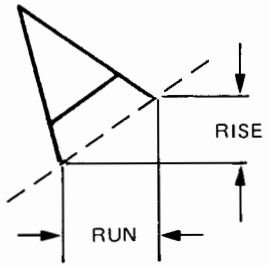
Syntax:

DI run, rise [; or LF]

Run and rise are in decimal format between ±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 ($|\text{parameter}| \geq 0.004$). 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.

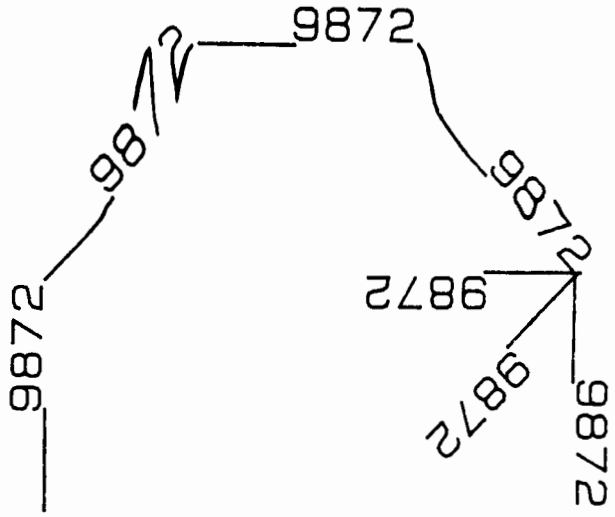
The following example letters the word 9872 in a circular pattern, starting with vertical lettering. The direction in which each line is labeled is changed by 45 degrees. The last three lines include a carriage return before leaving label mode. Note that the carriage return point is the beginning of 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;LB9872$E_x$
LINE 3. DI1,1;LB9872$E_x$
LINE 4. DI1,0;LB9872$E_x$
LINE 5. DI1,-1;LB9872$E_x$
LINE 6. DI0,-1;LB9872$C_R E_x$
LINE 7. DI-1,-1;LB9872$C_R E_x$
LINE 8. DI-1,0;LB9872$C_R E_x$

Result:





# The Relative Direction Instruction DR

The relative direction instruction DR specifies the direction in which characters are to be drawn 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:

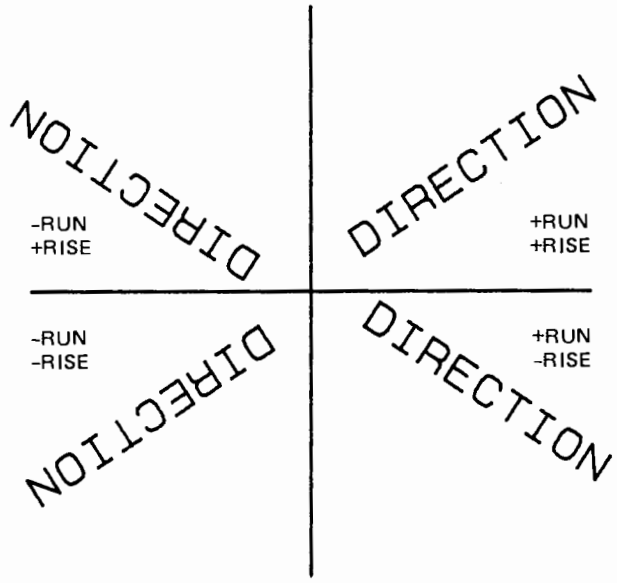
$$\frac{\text{rise}}{\text{run}}$$

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 for the 9872C or the 9872T with no roll paper loaded.




The algorithm used is more accurate with parameters greater than 1. While DR 2,3 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 when 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.

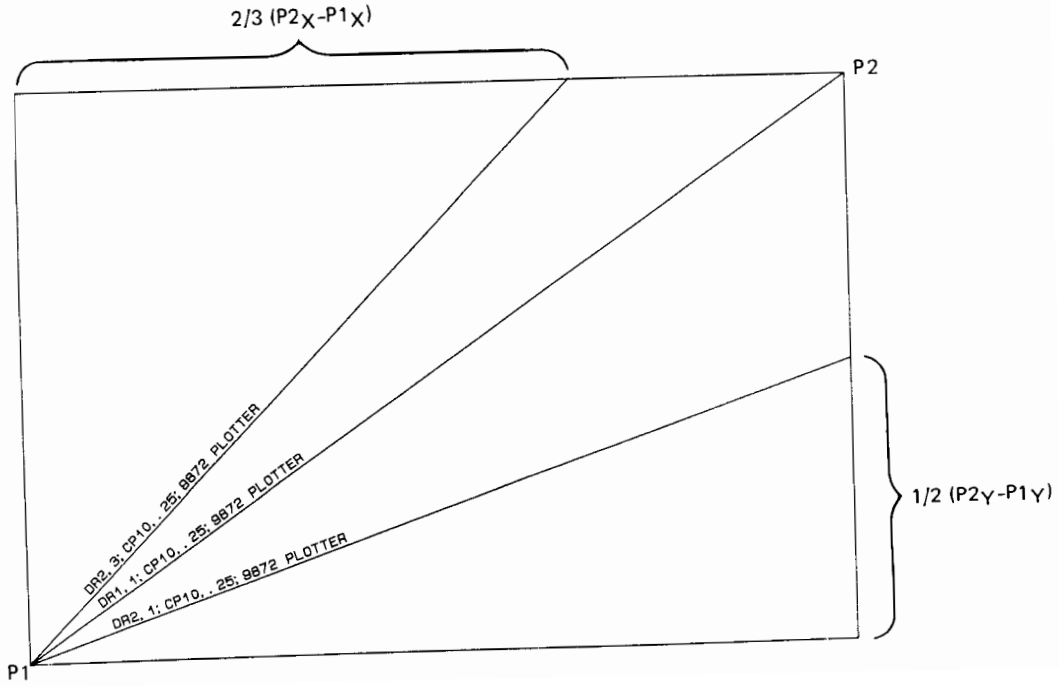
Form a fraction in lowest terms $\leq 1$ using the run and rise parameters. If run = rise the fraction will equal 1 and the directional line will go from P1 to P2. If run $>$ rise the directional line will intersect the side of the plotting area that fraction of the way up toward P2. If rise $>$ run 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.

Send:



```
LINE 1. IN;IP1000,1000,10000,7000;PA1000,1000;PD;
LINE 2. PA9000,0,0,6000,-9000,0,-0,-6000;PA10000,7000;
LINE 3. PU;PA1000,1000;DR1,1;CP10,.25;LBDR1,1;CP10,.25;9872 PLOTTER<ETX>
LINE 4. PU;PA1000,1000;PD;PA7000,7000;PU;
LINE 5. DR2,3;PA1000,1000;CP10,.25;LBDR2,3;CP10,.25;9872 PLOTTER<ETX>
LINE 6. PU;PA1000,1000;PD;PA10000,4000;PU;PA1000,1000;
LINE 7. DR2,1;CP10,.25;LBDR2,1;CP10,.25;9872 PLOTTER<ETX>
```



## The Absolute Character Size Instruction SI

The absolute character 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 between 0.004 and 127.999 and specify the width and height of upper case letters and numerals. In order to produce legible characters, parameters should be greater than .1. Parameter values above 25 will allow a maximum of one character on the platen area without invoking the out-of-limit condition.

An SI instruction with no parameters (SI; ) will default to the values 0.285 cm wide by 0.375 cm high. An SI command with invalid parameters will turn on the error light and character size will not change.

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

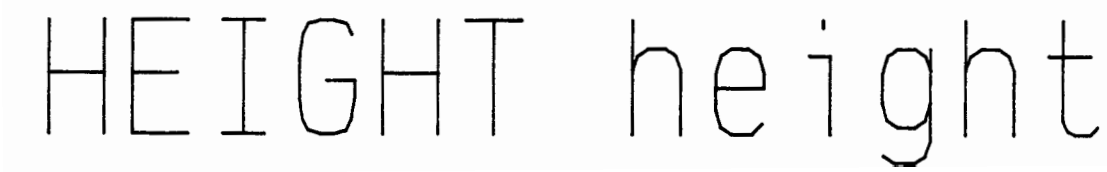


The following example writes the word height at a specified width of 0.75 cm and height of 1.5 cm in both upper and lower case characters.

Send:

```
SI.75,1.5;LBHEIGHT height
```

Result:



# The Relative Character Size Instruction SR

The relative character size instruction SR specifies 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.

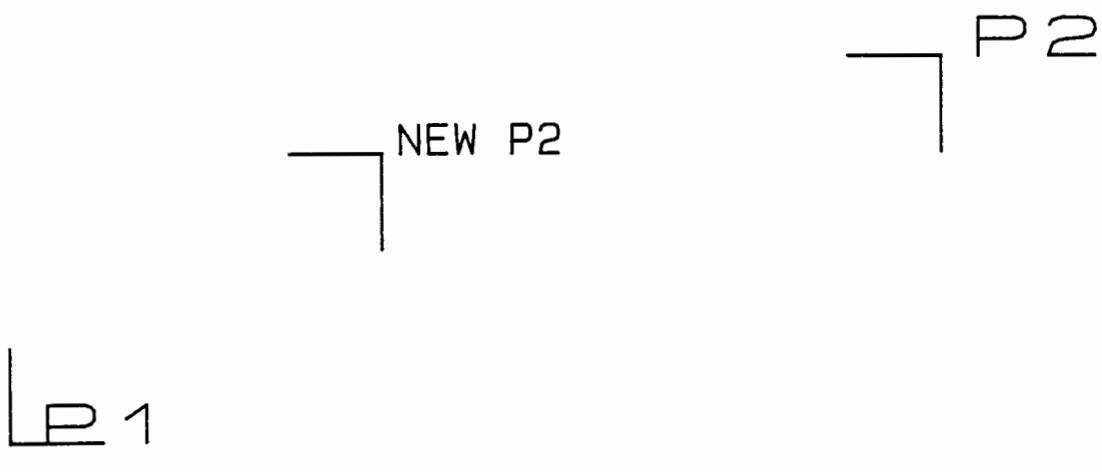
An SR command with no parameters (SR;) will default to the same values as SR .75,1.5. Negative and zero parameters are invalid and will cause the error light to be turned on and use of the last valid SR parameters, or the default values, if no SR or SI has been previously specified.

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.



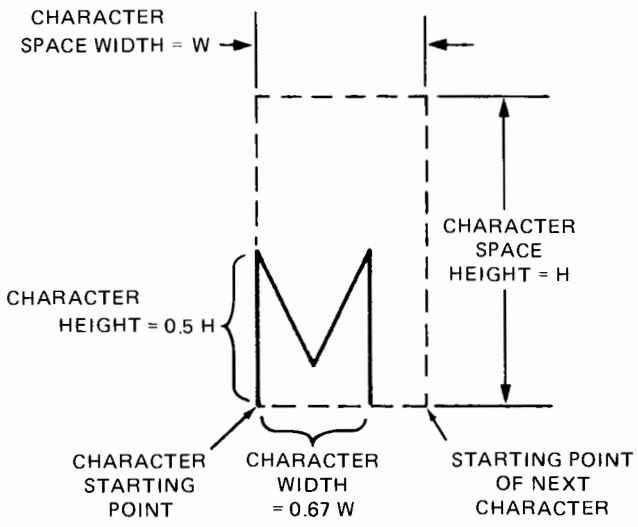
Note that character size will vary as P1 and P2 are changed. Character and line spacing are functions of character size. Refer to the next section, Spacing Between Characters. With default P1 and P2, the useful range of width and height parameters which produces legible characters and labels of suitable 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;SP1;
LINE 2. PA1000,1000;PD;PR500,0,-500,0,0,500;PU;PR200,-300;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
```



## 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.

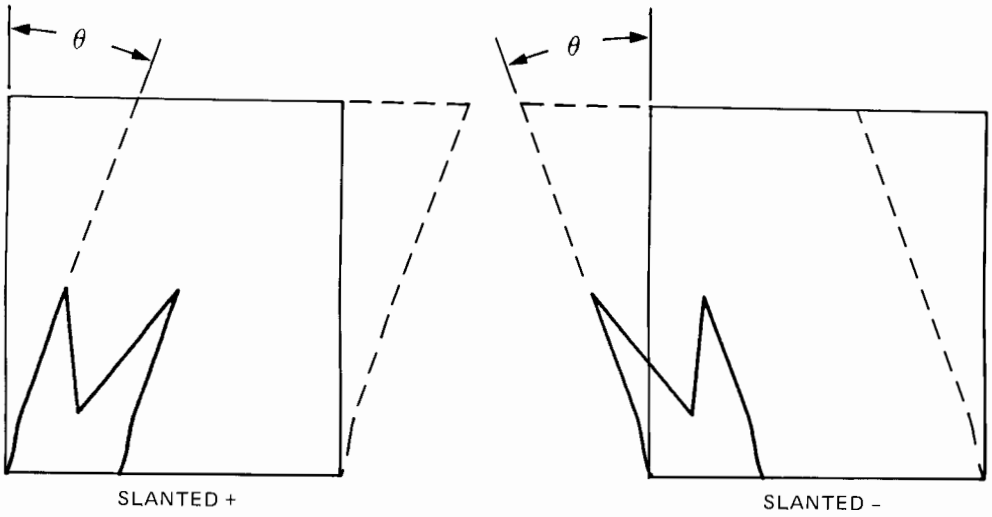
# The Character Slant Instruction SL

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

Syntax:

SL tan $\theta$ [; or LF]

The degree of slant is a decimal number between ±127.999 and is equivalent to the tangent of the angle $\theta$ 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.

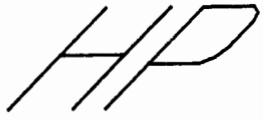
A change in scaling points P1 and P2 will not affect the angle $\theta$.

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 initialized or set to default conditions.

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

Send:

```
LINE 1. IN;IP200,200,3700,5500;SR10,10;
LINE 2. PA300,1000;SL1;LBHP[Ex]
```



## 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:

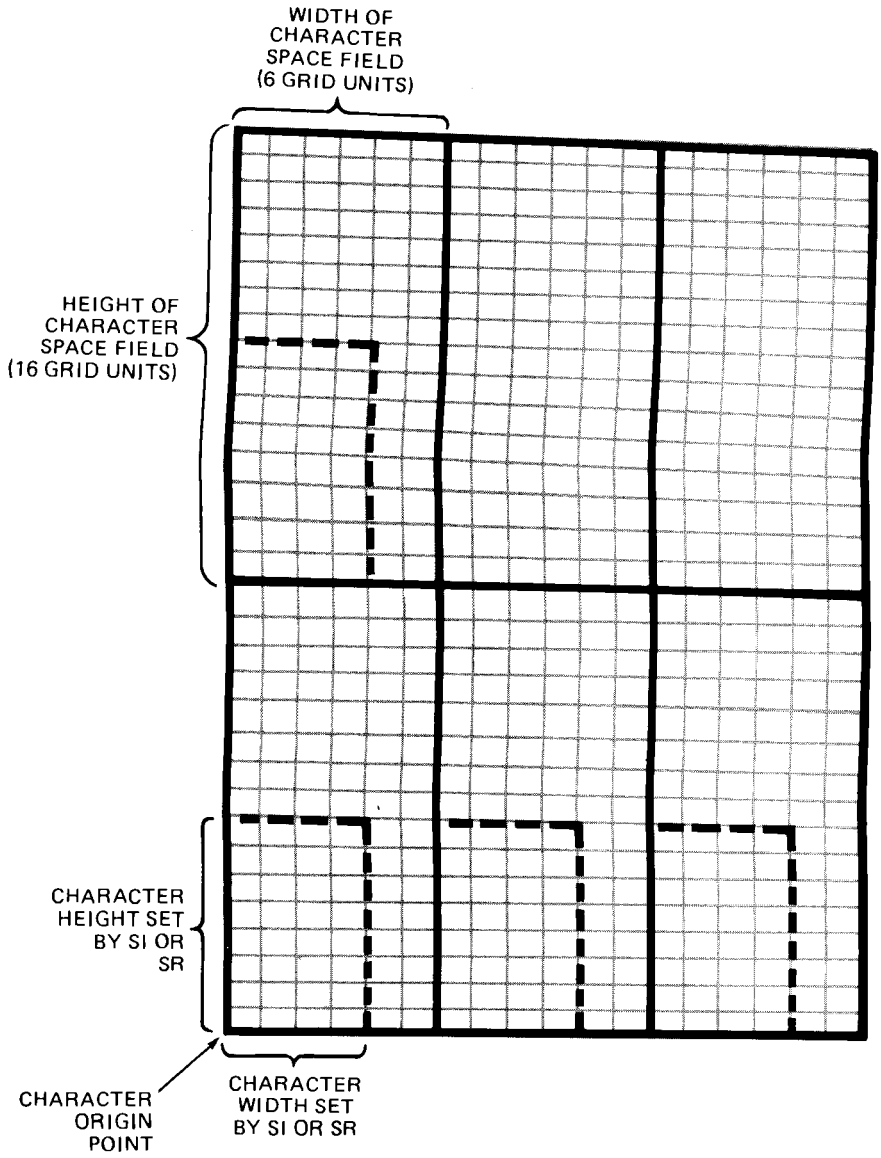
1. Pen control parameter — sets pen status with an integer entry of +99 for pen down or −99 for pen up. Once a pen down (+99) has been sent, the pen will remain down for the following X and Y increment moves, until a pen up (−99) is sent or the UC command is completed. The pen control parameter is internal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

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 through +99 will affect pen status in an unspecified manner.

For user defined characters only, each character space field is divided into 6 horizontal grid units and 16 vertical grid units. The size of the character-space field and the grid units is set by the current size command (SI or SR) as shown below. The size of the character-space field is always twice the specified character height and 1½ times the specified character width. In order to draw a user defined character the same size as a character drawn by the LB command, the user defined character must be designed within one character-space field with a width of 4 grid units by a height of 8 grid units.






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 with the pen up 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).

Each UC command must have at least one pen down parameter (+99) in order to draw anything. A UC command without a pen down (+99) will result in a pen movement of one character-space field horizontally. However, the purpose of the UC command is not to move the pen a specified number of character-space fields. Use the CP instruction (See the Character Plot Instruction, Chapter 6) for this.

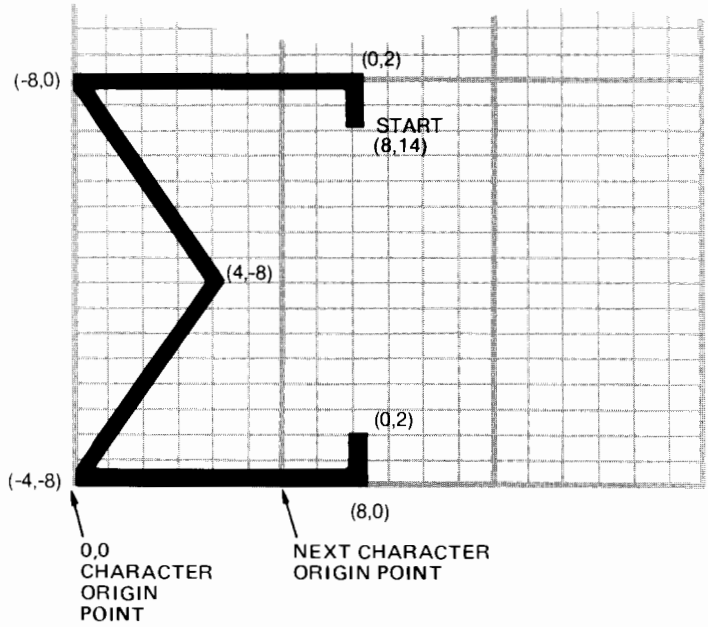
Plot commands (PA, PR, CP) which follow a UC command will be made using the pen status set by the previous PU or PD.

As shown in the next illustration, user defined characters are not limited to a single character-space field. If the user defined character is larger than one character-space field, a PA, PR, or CP instruction should be used to move the pen beyond the limits of the user defined character. Otherwise, the next character will be superimposed on the character just drawn. The parameters of a CP instruction used for this purpose are measured from the pen position at the completion of the UC command (one character-space field to the right of the user defined character's origin point).

The illustration below shows a Σ created by the following UC command.

UC8,14,99,0,2,−8,0,4,−8,−4,−8,8,0,0,2;






NOTE: THE NUMBERS IN PARENTHESES ARE X,Y INCREMENTS OF THE UC COMMAND.

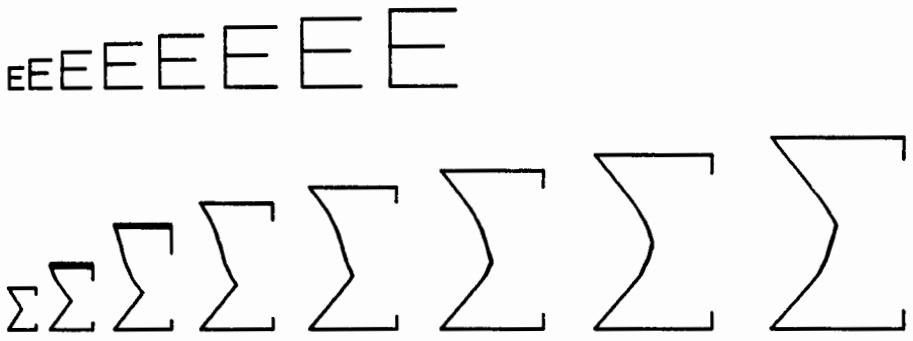
instruction and is included to show that the SI instruction has the same effect on both user defined characters and normal characters. The CP command in line 5 creates spacing between the Σ characters. It is only necessary when the user defined character does not fit in one character-space field.

```
  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  5. CP1,0;
■LINE  6. NEXT A
  LINE  7. PA1000,2000;
■LINE  8. FOR B=.19 TO .89 STEP .1
★LINE  9. SI,B,B+.08
  LINE 10. LBE
■LINE 11. NEXT B
```

6

UC

Result:

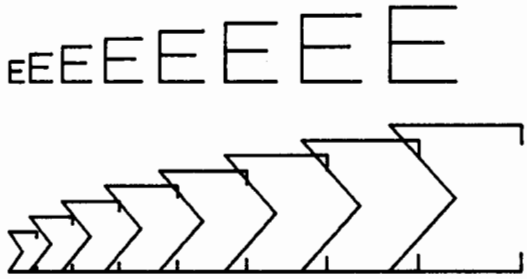


■BASIC statement. Do not send to plotter.

★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

Now send the above program with line 5 deleted. Notice that when the CP command is omitted, the character origin points for each symbol and its corresponding E are at the same horizontal location. Now the Σ symbols are partially superimposed because Σ is designed in two character-space fields and is twice as large as a standard upper case character, but the pen position on completion of a UC command is always only one character-space field to the right of the character origin point.

Result:



The size of user defined characters can be changed not only by the SI or SR commands, but also by dividing or multiplying the X,Y increments of the UC command. Change line 4 of the previous example by dividing each of the X,Y increment values by two. Now each symbol is only half as large as before, and is the same size as the E characters.



Send program with line 4 revised to be:

LINE 4. `UC 4,7,99,0,1,-4,0,2,-4,-2,-4,4,0,0,1;`

Result:

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

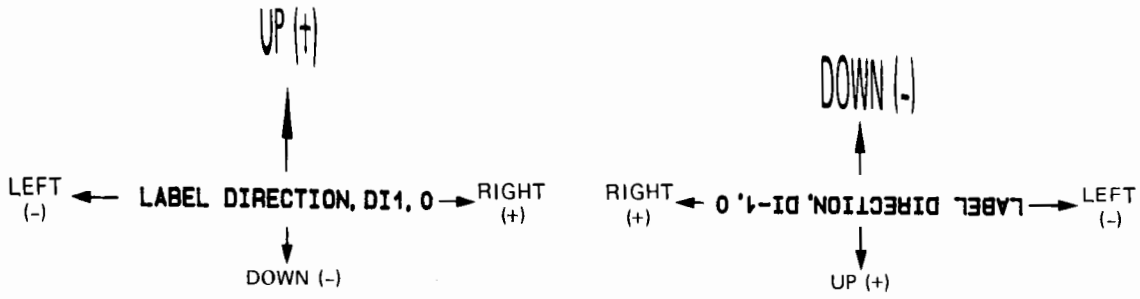
Syntax:

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 at the beginning of this chapter.

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:





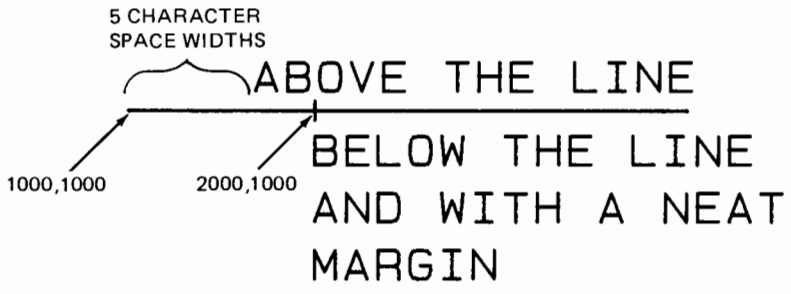

The pen's position (raised or lowered) does not change when a CP command is executed. The parameters must be within the range of ±127.999. However, since there are approximately 90 character-space field widths and 40 character-space field heights on the platen surface, assuming default sizing, the effective 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.

Send:

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

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.



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# Chapter 7
# Plot Enhancement

This chapter describes the instructions that enable you to enhance the plotted data with such things as axes and tick marks, special symbols, and programmable line types. 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;PR200,500;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 distance, $|P1_Y - P2_Y|$, when used with XT instructions, and a percentage of horizontal distance, $|P1_X - P2_X|$, when used with YT instructions. Note that "actual tick length" is a function of the scaling points P1 and P2. The length of ticks on the X- and Y-axes 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.

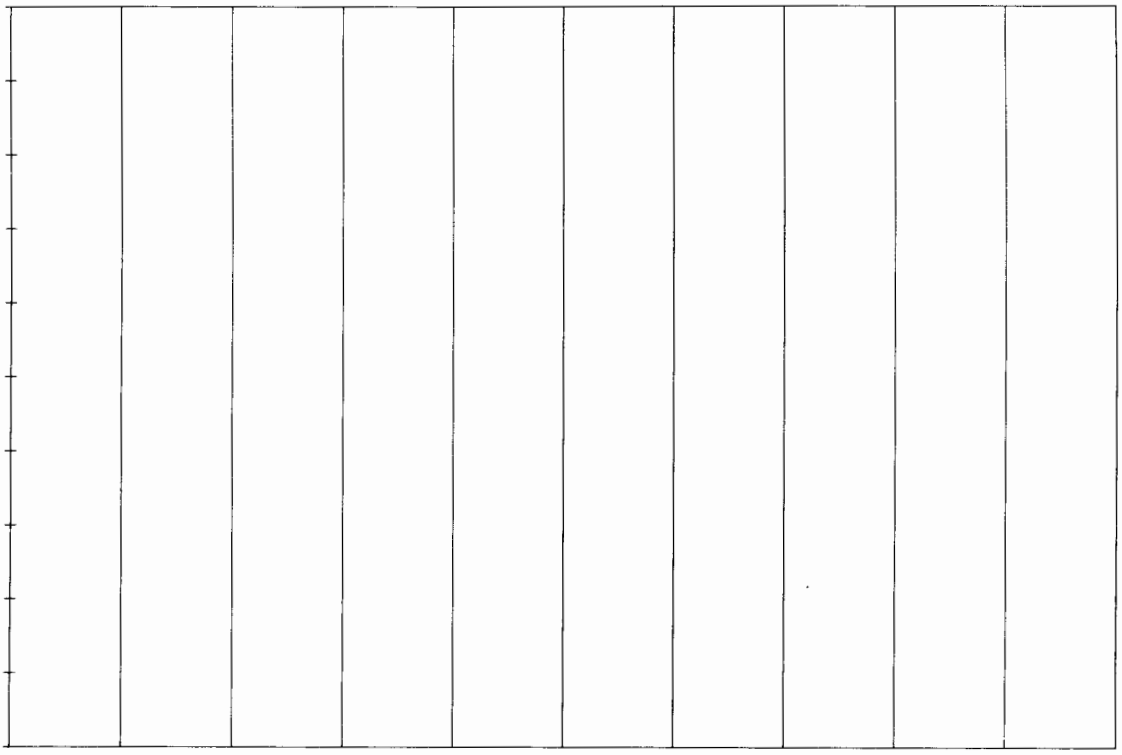


The plotter, when initialized, automatically sets the tick length values of 0.5% of $|P2_Y - P1_Y|$ for an XT command, and of $|P2_X - P1_X|$ for a YT command. The TL command with no parameters (TL;) will default to these same values. When only one parameter is included, it specifies the length of tp, 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 = 520,380 and P2 = 15720,10380 for a 9872C). The resulting vertical grid lines are 10000 plotter units in length (100% of 10380−380). 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.)

```
  LINE 1. IN;PR520,380;PD;TL100;XT;
■LINE 2. FOR I=1 TO 10
  LINE 3. PR1520,0;XT;
■LINE 4. NEXT I
  LINE 5. TL;PU;PR520,380;PD;YT;
■LINE 6. FOR J=1 TO 10
  LINE 7. PR0,1000;YT;
■LINE 8. NEXT J
  LINE 9. TL100;YT;PU;
```





■BASIC statement. Do not send to plotter.

# 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 and may be any printing character except ; (ASCII 59).

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 a non-printing or control character is specified, error 3 is set and the symbol mode is cancelled. 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 SM command is executed or the plotter is initialized or set to default conditions.

Since 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;SM0;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;SM0;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;SM0;PR-300,-400;SM;
LINE 7. PR300,400,-300,400;PU
```

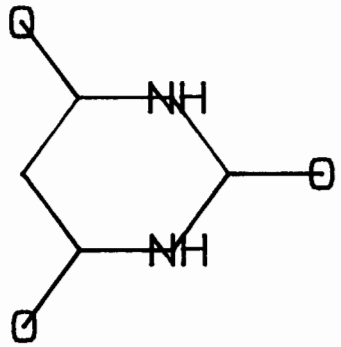
The program example under the Line Type Instruction which follows illustrates use of both symbol mode plotting and line types.

In order for the symbol to be 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.

In the molecule shown, in order to label the two characters NH, the use of the label command together with the CP instructions for centering is required. This is shown in line 3 and line 5.



Result:



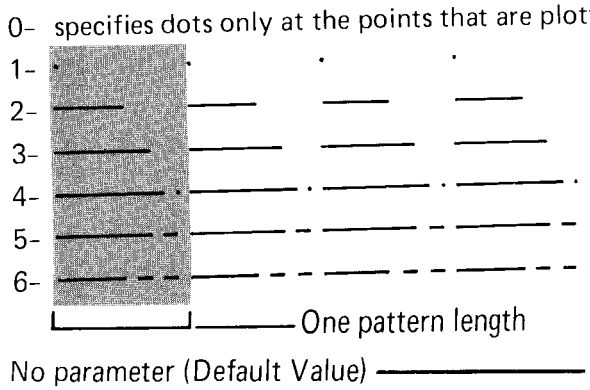
# The Line Type Instruction LT

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 pattern length parameters are between .004 and +127.999. Useful values for pattern length with default P1 and P2 are between 0.5 and 5 and depend somewhat on the pattern number.

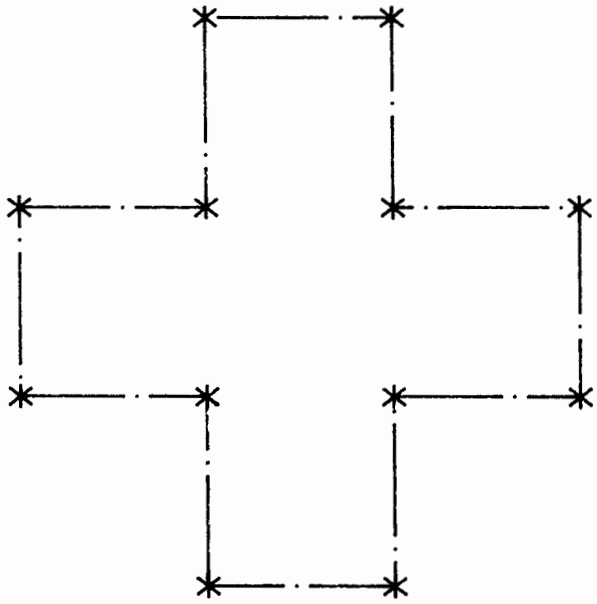
After this command, all subsequent vector commands with the pen down will cause the specified pattern to be drawn. Any portion of the pattern which is not used will be carried over into the next vector.

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 an * 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;
```



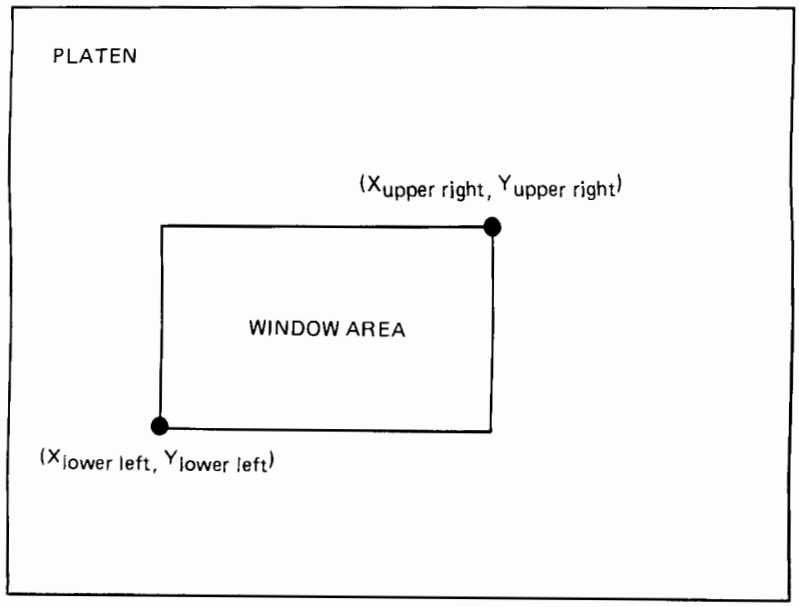
# The Input Window Instruction IW

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 16000 for X and 11400 for Y. Parameters between −32767 and 0 are set to 0 and parameters larger than the absolute plotting limits, but less than 32768 are set to the plotting limits (16000 for X and 11400 for Y). Parameters beyond ±32767 will cause an error and the window will not change.




7
IW

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 moved, 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.

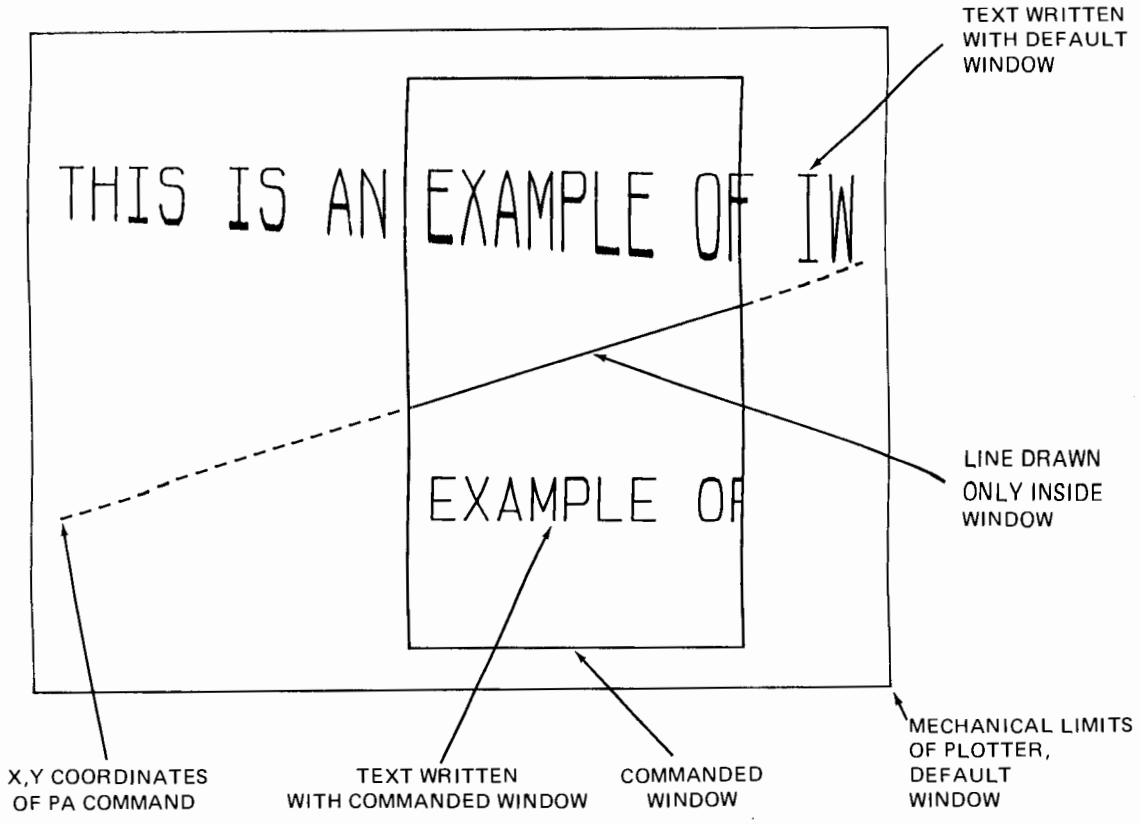
In type 5, the pen is raised and the OUT OF LIMIT light is on steady at the start of the vector. If part of the vector is in the window area, the plotter will move with the pen up to the intersection of the current vector and the window limit nearest the last point. The light will go out and pen will 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.

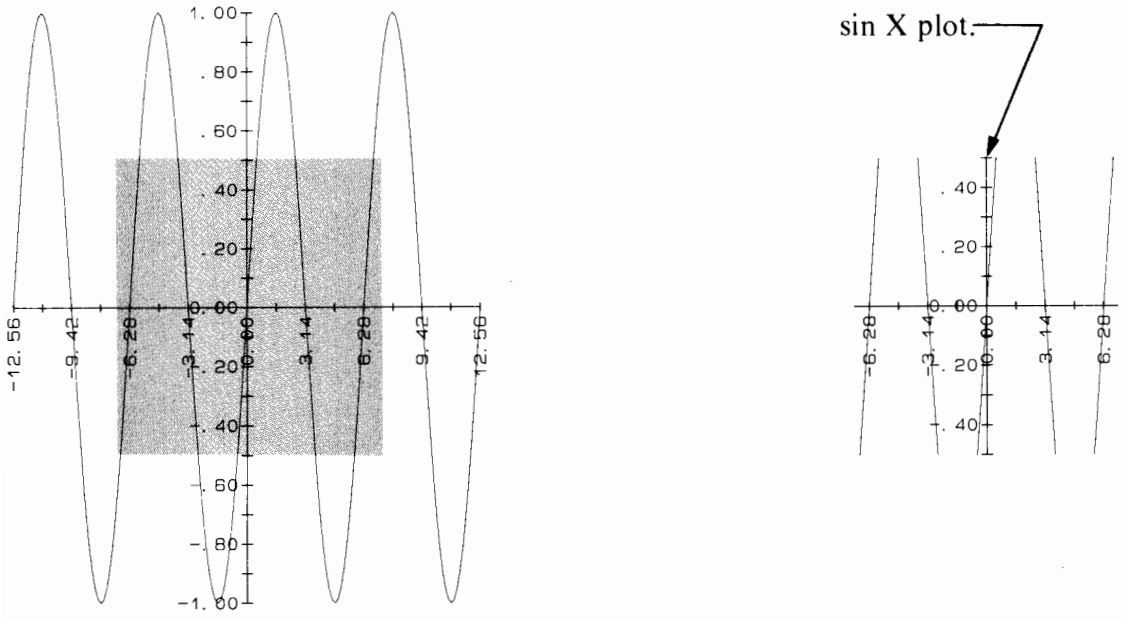



The input window command can be used to specify a limited portion of the plot. The following example plots the function sin X from $-4\pi$ to $4\pi$ and $-1$ to 1. The same program is then run, but with the window command inserted after IN; in line 1, to demonstrate the "windowing" effect. Both plots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

```
  LINE  1. IN;SP1;PA520,5000;PD;XT;
■LINE  2. FOR Xinterval=1 TO 16
  LINE  3. PR400,0;XT;
■LINE  4. NEXT Xinterval
  LINE  5. PU;PA520,5000;DIO,1;CP-6.5,-.25;
■LINE  6. FOR Xlabel =-12.56 TO 12.56 STEP 3.14
★LINE  7. LB Xlabel$_E$ CP-6,0;PU;PR800,0;
■LINE  8. NEXT Xlabel
  LINE  9. PA3720,1000;PD;YT;
■LINE 10. FOR Yinterval =1 TO 20
  LINE 11. PR0,400;YT;
■LINE 12. NEXT Yinterval
  LINE 13. PU;PA3720,500;DI;CP-6,0;
■LINE 14. FOR Ylabel =-1 TO 1 STEP .2
★LINE 15. LB Ylabel$_E$ CP-6,0;PU;PR0,800;
■LINE 16. NEXT Ylabel
■LINE 17. FOR X =-4*PI TO 4*PI STEP PI/20
■LINE 18. Xcoord =6400/25.12*X+3720
■LINE 19. Ycoord =4000*SIN(X)+5000
★LINE 20. PA Xcoord, Ycoord;PD;
■LINE 21. NEXT X
  LINE 22. PU;SP0;PA16000,11400;
```

```
IW1920,3000,5520,7000;
```

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




■BASIC statement. Do not send to plotter.

★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

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

When a DP command is received by the plotter, the ENTER light turns on indicating that a point can be entered. When the [ENTER •] pushbutton is pressed, the X- and Y-coordinates of the current pen position 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 digitizing sight provided with the plotter should be used when digitizing. When digitizing, the pen should be down.

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

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).

## 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 OS, Chapter 3).

When requested by the computer, 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. $0 \leqslant X \leqslant 16000$, $0 \leqslant Y \leqslant 11400$.

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



## Digitizing With the 9872

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 provided with the plotter allows you to visually position the pen over the point to be digitized. The digitizing sight should be inserted and removed from the pen holder manually. It is used in the pen down position.

---

**CAUTION**

The digitizing sight should never be placed in a pen stall of the front panel. Pen movements while a digitizing sight is present in a pen stall may cause damage to the plotter.

---

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 your program storage for 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, using the DP instruction, output the status byte, and monitor bit position 2 of the status byte for a true (1) condition. The true condition indicates that the [ENTER •] 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
```

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■BASIC statement. Do not send to plotter.

# The Output Actual Position and Pen Status Instruction OA

The output actual position and pen status instruction OA instructs the plotter to make 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 are made ready for output to the computer as ASCII integers in the following 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 is the mechanical limits of the plotter ($0 \leqslant X \leqslant 16000$, $0 \leqslant Y \leqslant 11400$). When the pen has been moved by program control, the range of the X,Y coordinates is the current window.

# The Output Commanded Position and Pen Status Instruction OC

The output commanded position and pen status instruction OC instructs the plotter to make the X- and Y-coordinates and pen status (up or down) associated with the last valid pen position instruction available for output.

Syntax:

OC [; or LF]

No parameters are used. However, the terminator ; or LF must be included to complete the command. 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 are made ready for 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, I = 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. When in scaled mode and in the lost state the plotter will output 32767 for both X and Y.

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# Chapter 9
# Automatic Paper Advance

The instructions in this chapter pertain only to the 9872T plotter which has automatic paper advance.

## The Advance Full Page Instruction AF

The advance full page instruction AF causes the paper to advance one full page.

Syntax:

AF [; or LF]
or
PG [; or LF]
or
PG1 [; or LF]

No parameters are used (PG1 is the only exception). However, the terminator ; or LF must be included to complete the command.

When the advance option is off, executing this instruction causes an error condition to be set (error 8). The advance option is off if sheet paper is being used, roll paper is not properly loaded, or the plotter is a 9872C.

When the advance option is on, the paper advances one full page, measured from the left edge of the platen at the time the advance command was initiated. This is 432 mm (17 inches) in English mode or 420 mm in metric mode.

If the cutter is on, the paper is cut along what was the left edge of the platen at the time the advance command was initiated. Lack of paper at the completion of an AF command will set the error condition (error 8). PG and PG1 are included to maintain compatibility with other Hewlett-Packard systems.

## The Advance Half Page Instruction AH

The advance half page instruction AH causes the paper to advance one half page.

Syntax:

AH [; or LF]

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

When the advance option is off, executing this instruction causes an error condition to be set (error 8). When the advance option is on, the paper advances one half page measured from the left edge of the platen at the time the advance command was initiated. A half page is 216 mm (8½ inches) in English mode or 210 mm in metric mode.

If the cutter is on, the paper is cut along what was the left edge of the platen at the time the advance command was initiated. Lack of paper at the completion of an AH command will set the error condition (error 8).

## The Enable Cutter Instruction EC

The enable cutter instruction EC turns the cutter on and off.

Syntax:

EC(int) [; or LF]

An EC command with no parameter (EC; ) turns the cutter on and the lamp in the front panel CUTTER ENABLE switch is turned on.

An EC command with integer parameter turns the cutter off and the lamp in the switch goes off. Zero is the recommended parameter to disable the cutter.

If the cutter is already on, the EC command with no parameters has no effect.

# Chapter 10
# Putting The Commands To Work

This chapter demonstrates the use of the 9872 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.

## Creating a Complete Graph

This example is a problem encountered in an engineering environment — the response of a system to a step input. However, the 9872 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 9872 has a range of $0 \leqslant X \leqslant 16000$ plotter units and $0 \leqslant Y \leqslant 11400$ plotter units. Allowing an additional 10% beyond the default P1 and P2 settings for the 9872C or the 9872T with chart advance off (P1 = 520,380 and P2 = 15720,10380) for labeling below the X-axis and to the left of the Y-axis, we set the scaling points to P1 = 2000,1400 and P2 = 14200,9300 using the IP instruction.

LINE 1. `IN;IP2000,1400,14200,9300;`

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 9872 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:

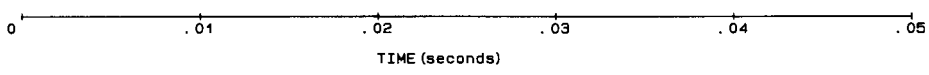
LINE 2. `SC0,500,0,1600;`

Since $10000 \times 0.05 = 500$ (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. `PA0,0;SP1;PD;`
■LINE 4. `FOR X=0 TO 500 STEP 100`
★LINE 5. `PAX,0;XT;PU;`
★LINE 6. `CP-2.4,-.9;LB,X/10000,E`
★LINE 7. `PAX,0;PD;`
■LINE 8. `NEXT X`
LINE 9. `PU;PA 200,-125;LBTIME (seconds)E`

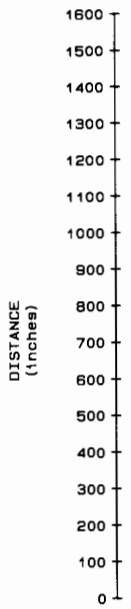



■BASIC statement. Do not send to plotter.
★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

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. 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;DIO,1;LBDISTANCE CR LF (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

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



■BASIC statement. Do not send to plotter.

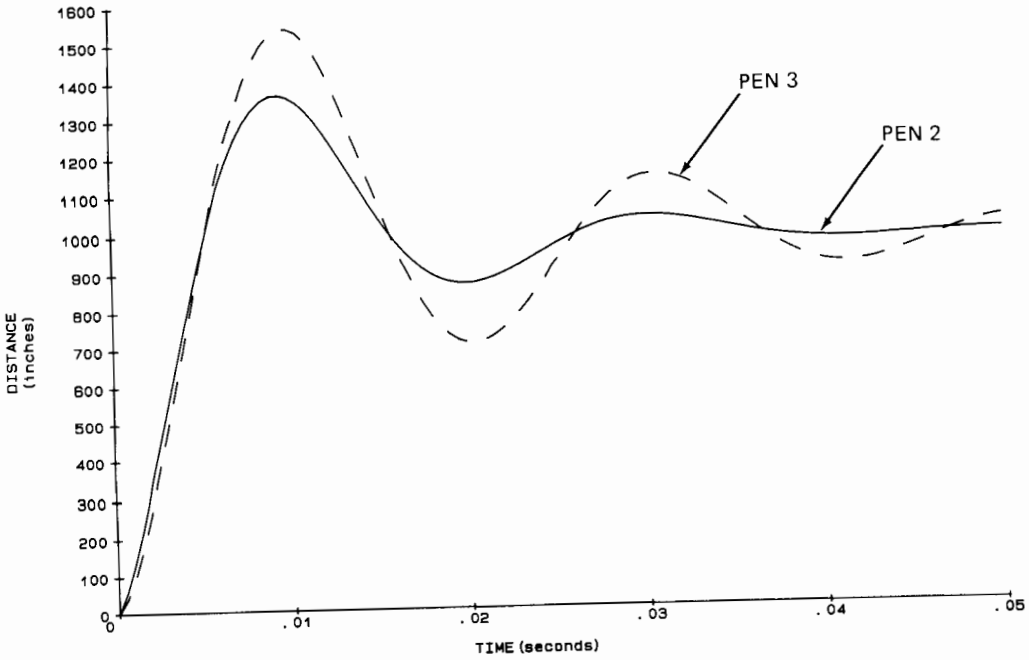
★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

```
LINE 17. PA0,0;SP2;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 pen and line type for trace differentiation, the following instructions plot the equation

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

```
LINE 23. PU;PA0,0;SP3;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
```




10

■BASIC statement. Do not send to plotter.

★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

F. Add the test data

The test data can be plotted on the same graph for comparison with the ideal curves.

---

**NOTE**

Test data could be stored on a mass storage device. Accessing stored test data varies depending on the type of storage device and your computer. Refer to your computer operating and programming manual for specific instructions for loading test data into your computer.

---

The following steps illustrate plotting test data by incrementing the T value in fixed steps and reading the corresponding test value from data statements. Line 29 specifies plotting the data in a different pen and line type for ease of comparison with the ideal curves.

The test data as given in the DATA statements had been divided by 10000. To restore it to the original range, it is multiplied by 10000 in line 32 to give the Y parameter for the plot. The T values are multiplied by the appropriate multiplier to obtain the X parameters for the plot.

```
  LINE 29. PU;PA0,0;SP4;PD;LT6;
■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. SP0;
■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,.092
■LINE 42. DATA .093,.091,.088,.097,.093,.1,.093,.088,.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,.099,.104,.102,.099
■LINE 48. DATA .097,.088,.101,.102
```

■BASIC statement. Do not send to plotter.

★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

G. The completed effort

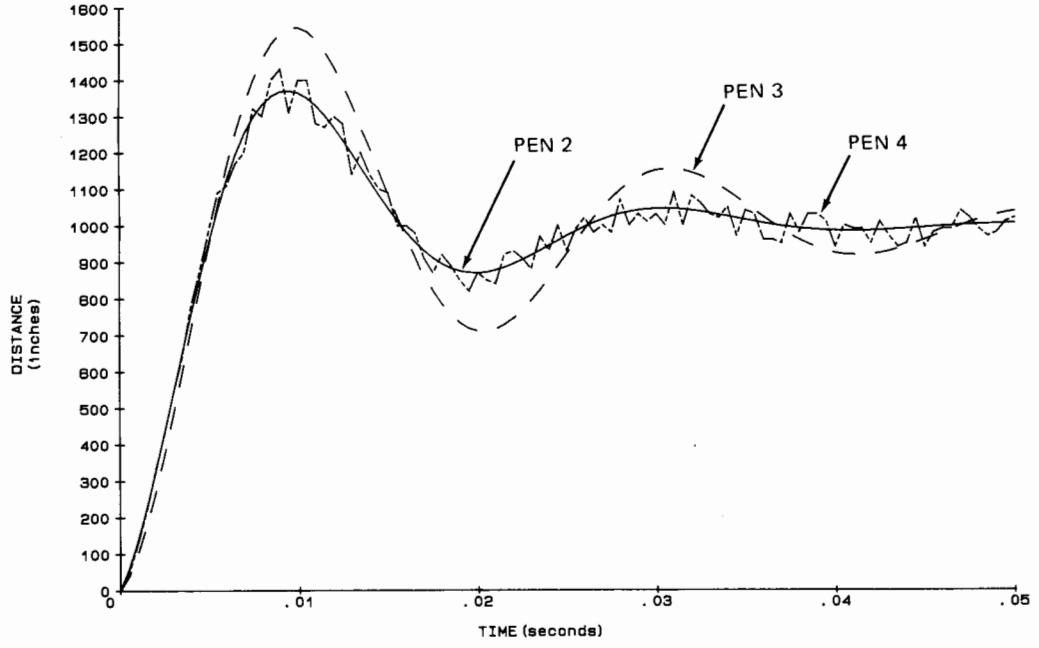
The whole program which plots the ideal and actual data is given below. Note that using different line types and pens for the three lines makes the plotted results easy to read.

```
  LINE  1. IN;IP2000,1400,14200,9300;
  LINE  2. SC0,500,0,1600;
  LINE  3. PA0,0;SP1;PD;
■LINE  4. FOR X=0 TO 500 STEP 100
★LINE  5. PA X,0;XT;PU;
★LINE  6. CP-2.4,-.9;LBX/10000,Ex
★LINE  7. PA X,0;PD;
■LINE  8. NEXT X
  LINE  9. PU;PA200,-125;LBTIME(seconds)Ex
  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,Ex
★LINE 14. PA0,Y;PD;
■LINE 15. NEXT Y
  LINE 16. PU;PA-55,600;DIO,1;LBDISTANCE CR LF (inches)Ex
  LINE 17. PA0,0;SP2;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;SP3;PD;LT2;
■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;SP4;PD;LT6;
■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. SP0;
```

■BASIC statement. Do not send to plotter.

★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

■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,.092
■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,.085,.103,.098,.103,.103,.101
■LINE 46. DATA .094,.1,.099,.099,.095,.101,.097,.094,.095
■LINE 47. DATA .102,.094,.098,.099,.099,.104,.102,.099
■LINE 48. DATA .097,.098,.101,.102




10

■BASIC statement. Do not send to plotter.

## Suggested Programming Practices

Certain programming practices will assure more effective use of the plotter. Among these are:

1. Initialize the plotter with the IN or DF command at the beginning of each program to assure no unwanted parameters are in effect from a prior plot. Use of IN will set P1 and P2 to default conditions and enable cutter on 9872T only. Use of DF will not alter P1 or P2 or assure that cutter is enabled.

2. With 9872T when operating from a remote terminal, use output option OO command to ascertain if paper advance is on and if paper has been written on. Advance the paper at the completion of your plot to assure no other user draws over your plot.

3. Select a pen before the first plot command to assure plot is actually recorded on the paper.

4. Lift the pen before changing colors to avoid a dot of the new color at the termination of the last vector.

5. Store the pen (SP0) at the completion of a plot so pens do not dry out.

6. When using A3 or 8½ × 11 in. paper, reset P1 and P2 manually or programmatically to points inside the paper area. Default P2 will scale the plot beyond the limits of 8½ by 11 in. paper.

7. When setting up the 9872T for unattended operation you may wish to load your plotter with a new set of pens. Pens have sufficient ink to draw 140 "typical" full page plots (1 roll) where each plot consists of 10 linear feet of writing per pen (axes, labels, and lines). If your plots differ from this norm you may wish to change pens more or less frequently.

# 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 device's 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 sytem. 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.

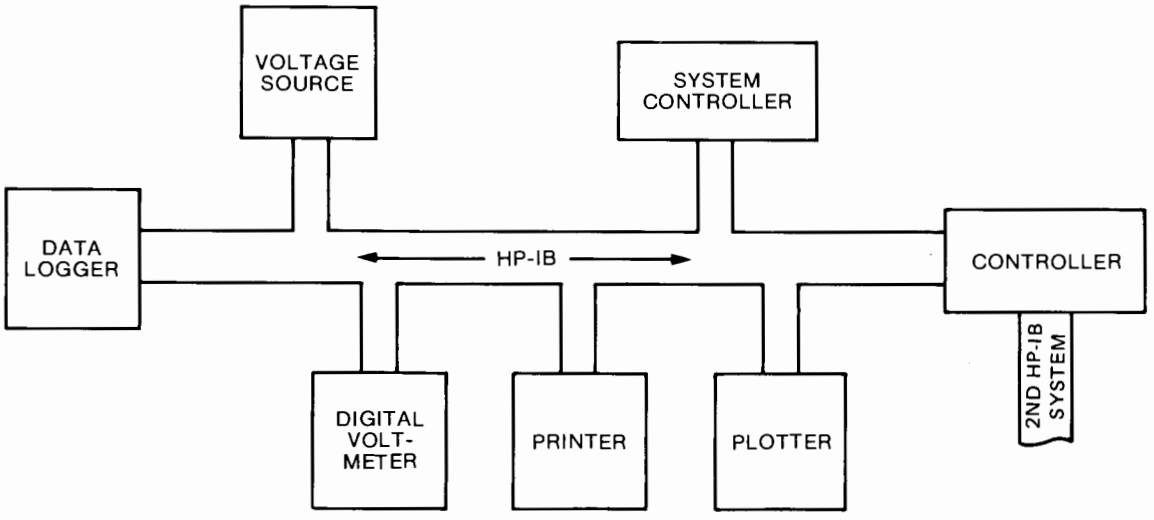
2. **Listeners** — Devices which receive information sent on the bus when they have been addressed.

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.




9872-A-172-1

## 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 device'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).

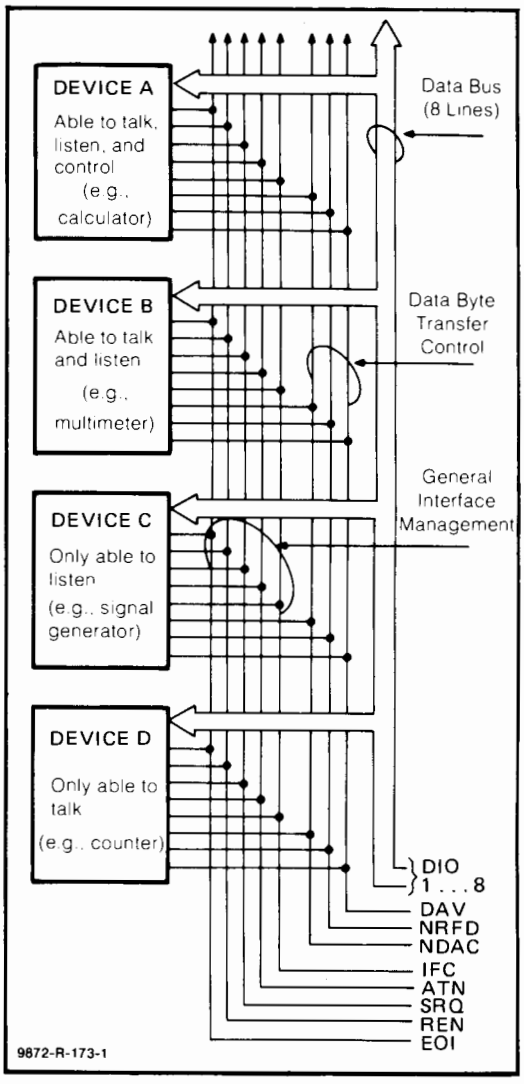
These messages represent the full implementation of all HP-IB system capabilities. Each device in a system may be designed to use only the messages that are applicable to its purpose in the system. It is important for you to be aware of the HP-IB functions implemented on each device in your HP-IB system 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 (DIO1 through DIO8) are reserved for the transfer of data and other messages in a byte-serial, bit-parallel manner. Data and message transfer is asynchronous, coordinated by the three handshake lines: Data Valid (DAV), Not Ready For Data (NRFD), and Not Data Accepted (NDAC). The other five lines are for management of bus activity. See the figure on the right.




HP-IB Signal Lines

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

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

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

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

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

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

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

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

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

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

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

The commands serve several different purposes:

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

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

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

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

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

Interface functions provide the physical capability to communicate via HP-IB. These functions are defined in the ANSI/IEEE 488-1978 Standard. This standard, which is the designer's guide to the bus, defines each interface function in terms of state diagrams that express all possible interactions.

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

HP-IB Interface Functions

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

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

## Bus Messages

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

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

Functions Used By Each Bus Message

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

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

# HP 9872 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 (L2)
   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 |
|---|---|
| $4 \times 10^1 + 1 \times 10^0$ | $1 \times 2^5 + 0 \times 2^4 + 1 \times 2^3 + 0 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$ |
| $40 \times 1 + 1 \times 1$ | $1 \times 32 + 0 \times 16 + 1 \times 8 + 0 \times 4 + 0 \times 2 + 1 \times 1$ |
| 4 $1_{10}$ | 1 0 1 0 0 $1_2$ |

### 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 | ⟌41 | → | 1 | |
| 2 | ⟌20 | → | 0 | |
| 2 | ⟌10 | → | 0 | |
| 2 | ⟌ 5 | → | 1 | = Binary 101001 |
| 2 | ⟌ 2 | → | 0 | |
| 2 | ⟌ 1 | → | 1 | |

## Scaling Without Using the SC Instruction

The 9872 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:

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

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

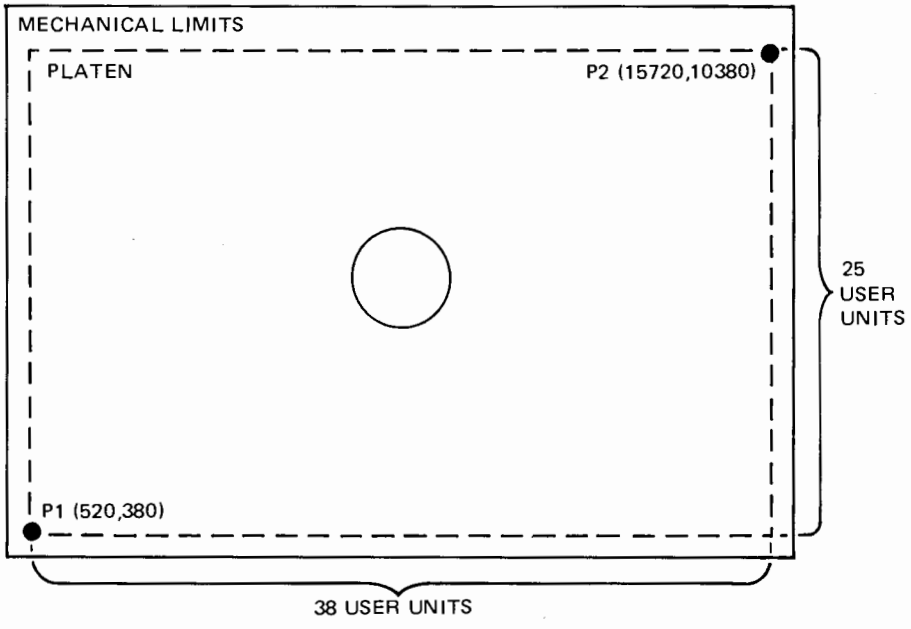
where: $A_X$ is the X-coordinate of the desired point in user units
$A_Y$ is the Y-coordinate of the desired point in user units
$P1_X$ is the X-coordinate of P1 in plotter units
$P1_Y$ is the Y-coordinate of P1 in plotter units
$P2_X$ is the X-coordinate of P2 in plotter units
$P2_Y$ is the Y-coordinate 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 = 520,380 and P2 = 15720,10380) into user units where P1 = 0,0 and P2 = 38,25 cm. At the center point (X = 19, Y = 12.5 cm), draw a 2.5 cm radius circle as follows:



Solution

A. Recall that the equations of a circle are

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

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

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

C. The desired circle equations are then:

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

D. Determine the user scale:

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

therefore

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

E. Determine the values for P1 and P2 which were set using the IP command:

$$P1 = 520,380$$
$$P2 = 15720,10380$$

therefore

$$P1_X = 520$$
$$P1_Y = 380$$
$$P2_X = 15720$$
$$P2_Y = 10380$$

F. Solving for X and Y:

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

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

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

$$= 1000 \cos t + 8120$$

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

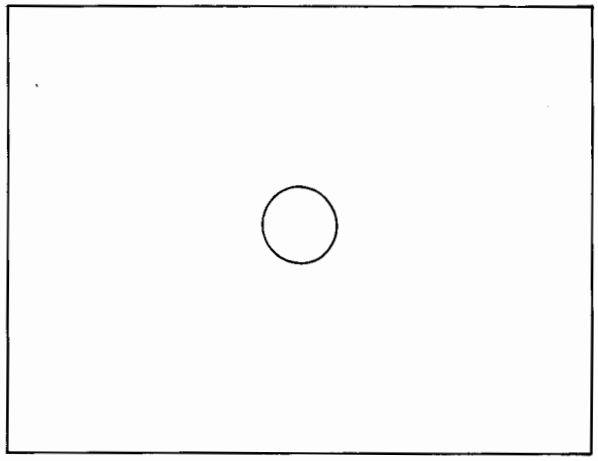
$$+ \left[\frac{10380 - 380}{25 - 0}\right][2.5 \sin t + 12.5] + 380 - 0\left[\frac{10380 - 380}{25 - 0}\right]$$

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

$$= 1000 \sin t + 5380$$

G. The following program will plot the required circle using the default P1 and P2 for a 9872C or 9872T with no roll paper loaded. Only lines 1, 5, and 7 are sent to the plotter.

```
  LINE 1. IP520,380,15720,10380;
■LINE 2. FOR T=0 TO 2*PI STEP PI/20
■LINE 3. X=1000*COS(T)+8120
■LINE 4. Y=1000*SIN(T)+5380
★LINE 5. PA X,Y;PD;
■LINE 6. NEXT T
  LINE 7. PU;
```



B

■BASIC statement. Do not send to plotter.

★A controller-dependent format statement may be required for this statement to be accepted by the plotter.

# Plotter Default Conditions

| | |
|---|---|
| Relative character direction | Horizontal (DR1,0) |
| Line type | Solid line |
| Line pattern length | 4% of the distance from P1 to P2 |
| Input window | Mechanical limits of plotter |
| Relative character size | (SR.75, 1.5)<br>width = 0.75% of $\lvert P2_X - P1_X \rvert$<br>height = 1.5% of $\lvert P2_Y - P1_Y \rvert$ |
| Scale | Off |
| Symbol mode | Off |
| Tick length (on either side of axis) | 0.5% of $\lvert P1_X - P2_X \rvert$ or $\lvert P1_Y - P2_Y \rvert$ for tp or tn |
| Standard character set | Set 0 |
| Alternate character set | Set 0 |
| Character slant | 0° |
| Mask value | 223,0,0 |
| Digitize clear | On |
| Automatic pen pickup | On |
| Pen velocity | 36 cm/sec |
| Adaptive pen velocity | Off |



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

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

On the 9872T the cutter is enabled only with the IN command (IN). It is not affected by the default command (DF) or the bus command, device clear.

# Error Messages

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

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

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

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

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

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

error 8
Out of paper
Either the advance option is off when an AH or AF is attempted or the out-of-paper sensor indicates no paper after an advance.

# 9872 HP-GL Command Syntax

This section lists the formal syntax for each plotter instruction. The instructions are listed in alphabetical order (by mnemonic).

## Parameter Range Restrictions

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

## AF Advance Full Page Instruction

Page 113

AF [; or LF] or PG [; or LF] or PG1 [; or LF]

Parameters are not used. These instructions are not usable on the 9872C plotter.

## AH Advance Half Page Instruction

Page 114

AH [; or LF]

Parameters are not used. AH is not usable on the 9872C plotter.

## AP Automatic Pen Pickup Instruction

Page 62

AP (int) [; or LF]

No parameter enables automatic pen pickup. An integer parameter disables automatic pen pickup.

## CA Designate Alternate Character Set Instruction

Page 73

CA 0 through 4 [; or LF]

If the parameter is omitted, default value is assumed.

## CP Character Plot Instruction

Page 92

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.

## CS Designate Standard Character Set Instruction

Page 73

CS 0 through 4 [; or LF]

If the parameter is omitted, default value is assumed.

## DC Digitize Clear Instruction

Page 107

DC [; or LF]

Parameters are not used. DC should not be used in listen-only mode.

## DF Default Instruction

Page 39

DF [; or LF]

Parameters are not used.

## DI Absolute Direction Instruction

Page 79

DI run, rise [; or LF]

Both parameters must be in the range of ±127.999. At least one must be non-zero i.e.: |parameter| ⩾ 0.004. If the parameters are omitted, default values are assumed.

## DP Digitize Point Instruction

Page 107

DP [; or LF]

Parameters are not used. DP should not be used in listen-only mode.

## DR Relative Direction Instruction

Page 81

DR run as % of $|P2_X - P1_X|$, rise as % of $|P2_Y - P1_Y|$

Both parameters must be in the range of ±127.999. If the parameters are omitted, default values are assumed. Parameters $> 1$ or $< -1$ preferred.

## EC Enable Cutter Instruction

Page 114

EC (int) [; or LF]

EC with no parameter enables the cutter. Zero is the only recommended parameter to disable cutter. EC is not usable on the 9872C plotter.

## IM The Input Mask Instruction

Page 41

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



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

## IN The Initialize Instruction

Page 40

IN [; or LF]

Parameters are not used.

## IP Input P1 and P2 Instruction

Page 52

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

Parameters must be within the mechanical limits of the plotter $0 \leqslant X \leqslant 16000$, $0 \leqslant Y \leqslant 11400$. If the parameters are omitted, default values are assumed.

## IW The Input Window Instruction

Page 102

IW $X_{\text{lower left}}$, $Y_{\text{lower left}}$, $X_{\text{upper right}}$, $Y_{\text{upper right}}$ [; or LF]

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

## LB Label Instruction

Page 71

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

## LT Line Type Instruction

Page 100

LT pattern number (, pattern length) [; or LF]

The range of pattern number is 0 through 6 and the range of pattern length is 0.004 to 127.999. If the parameters are omitted, default values are assumed.

## OA Output Actual Position and Pen Status Instruction

Page 110

OA [; or LF]

Parameters are not used. OA should not be used in listen-only mode.

## OC Output Commanded Position and Pen Status Instruction

Page 111

OC [; or LF]

Parameters are not used. OC should not be used in listen-only mode.

## OD Output Digitized Point and Pen Status Instruction

Page 108

OD [; or LF]

Parameters are not used. OD should not be used in listen-only mode.

## OE Output Error Instruction

Page 43

OE [; or LF]

Parameters are not used. OE should not be used in listen-only mode.

## OF Output Factors Instruction

Page 44

OF [; or LF]

Parameters are not used. OF should not be used in listen-only mode.

## OI Output Identification Instruction

Page 45

OI [; or LF]

Parameters are not used. OI should not be used in listen-only mode.

## OO Output Options Instruction

Page 46

OO [; or LF]

Parameters are not used. OO should not be used in listen-only mode.

## OP Output P1 and P2 Instruction

Page 53

OP [; or LF]

Parameters are not used. OP should not be used in listen-only mode.

## OS Output Status Instruction

Page 47

OS [; or LF]

Parameters are not used. OS should not be used in listen-only mode.

## PA Plot Absolute Instruction

Page 65

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

X and Y coordinates must be integers and are limited to the range ±32767 with scaling off and ±16383 with scaling on.

## PD Pen Down

Page 62

PD [; or LF]

Parameters are not used.

## PG Advance Full Page Instruction See AF

## PR Plot Relative Instruction

Page 68

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

X and Y increments must be integers and are limited to values between ±32767 with scaling off and between ±16383 with scaling on. Result of adding increment to current X and Y pen position must be between ±32767 plotter units when referenced from platen point 0,0 with scaling off and ±16383 with scaling on.

## PU Pen Up Instruction

Page 62

PU [; or LF]

Parameters are not used.

## SA Select Alternate Character Set Instruction

Page 74

SA [; or LF]

Parameters are not used.

## SC Scale Instruction

Page 54

SC $X_{min}$, $X_{max}$, $Y_{min}$, $Y_{max}$, [; or LF]

All four parameters must be entered as integers and be in the range ±16383. Xmax must be greater than Xmin and Ymax must be greater than Ymin.

### SI Absolute Character Size Instruction

Page 83

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.

### SL Character Slant Instruction

Page 86

SL decimal number [; or LF]

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

### SM Symbol Mode Instruction

Page 98

SM character [; or LF]

Character is limited to any printing character except ; (ASCII 59). If the parameter is omitted, default value is assumed.

### SP Pen Select Instruction

Page 61

SP pen number [; or LF]

The range of the pen number is 0 through 8.

### SR Relative Character Size Instruction

Page 84

SR width as % of $|P2_X - P1_X|$, height as % of $|P2_Y - P1_Y|$

Both parameters must be in the range of 0.004 to 127.999. If the parameters are omitted, default values are assumed.

### SS Select Standard Character Set Instruction

Page 75

SS [; or LF]

Parameters are not used.

### TL Tick Length Instruction

Page 96

TL tp (, tn) [; or LF]

Both parameters must be in the range of 0 to 127.999. If both parameters are omitted, default values are assumed.

## UC User Defined Character Instruction

Page 87

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

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

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

## VA Adaptive Pen Velocity Instruction

Page 64

VA [; or LF]

Parameters are not used.


## VN Normal Velocity Instruction

Page 64

VN [; or LF]

Parameters are not used.

## VS Velocity Select Instruction

Page 63

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

The pen velocity parameter must be an integer in the range of 1 through 36. The pen number an integer in the range 1 through 8. If no parameters are specified, default values are assumed.

## XT X-Tick Instruction

Page 95

XT [; or LF]

Parameters are not used.

## YT Y-Tick Instruction

Page 95

YT [; or LF]

Parameters are not used.

# ASCII Character Codes

Binary is often used as a code to represent not only numbers, but also alphanumeric characters such as "A" or "," or "?" or "x" or "2". One of the most common binary codes used is ASCII.[1] ASCII is an eight-bit code, containing seven data bits and one parity bit. The plotter uses ASCII for most I/O operations. The parity bit is ignored by the plotter. For example:

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

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



[1] American Standard Code for Information Interchange.

# Plotter ASCII Code Definitions

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

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

# Plotter ASCII Code Definitions (Continued)

| Decimal Code | ASCII Character | 9872 Function/Character Set | | | | |
|---|---|---|---|---|---|---|
| | | Set 0 | Set 1 | Set 2 | Set 3 | Set 4 |
| 45 | — | – | – | – | – | – |
| 46 | . | . | . | . | . | . |
| 47 | / | / | / | / | / | / |
| 48 | 0 | 0 | 0 | 0 | 0 | 0 |
| 49 | 1 | 1 | 1 | 1 | 1 | 1 |
| 50 | 2 | 2 | 2 | 2 | 2 | 2 |
| 51 | 3 | 3 | 3 | 3 | 3 | 3 |
| 52 | 4 | 4 | 4 | 4 | 4 | 4 |
| 53 | 5 | 5 | 5 | 5 | 5 | 5 |
| 54 | 6 | 6 | 6 | 6 | 6 | 6 |
| 55 | 7 | 7 | 7 | 7 | 7 | 7 |
| 56 | 8 | 8 | 8 | 8 | 8 | 8 |
| 57 | 9 | 9 | 9 | 9 | 9 | 9 |
| 58 | : | : | : | : | : | : |
| 59 | ; | ; | ; | ; | ; | ; |
| 60 | < | < | < | < | < | < |
| 61 | = | = | = | = | = | = |
| 62 | > | > | > | > | > | > |
| 63 | ? | ? | ? | ? | ? | ? |
| 64 | @ | @ | @ | @ | @ | @ |
| 65 | A | A | A | A | A | A |
| 66 | B | B | B | B | B | B |
| 67 | C | C | C | C | C | C |
| 68 | D | D | D | D | D | D |
| 69 | E | E | E | E | E | E |
| 70 | F | F | F | F | F | F |
| 71 | G | G | G | G | G | G |
| 72 | H | H | H | H | H | H |
| 73 | I | I | I | I | I | I |
| 74 | J | J | J | J | J | J |
| 75 | K | K | K | K | K | K |
| 76 | L | L | L | L | L | L |
| 77 | M | M | M | M | M | M |
| 78 | N | N | N | N | N | N |
| 79 | O | O | O | O | O | O |
| 80 | P | P | P | P | P | P |
| 81 | Q | Q | Q | Q | Q | Q |
| 82 | R | R | R | R | R | R |
| 83 | S | S | S | S | S | S |
| 84 | T | T | T | T | T | T |
| 85 | U | U | U | U | U | U |
| 86 | V | V | V | V | V | V |
| 87 | W | W | W | W | W | W |
| 88 | X | X | X | X | X | X |
| 89 | Y | Y | Y | Y | Y | Y |

# Plotter ASCII Code Definitions (Continued)

| Decimal Code | ASCII Character | 9872 Function/Character Set | | | | |
|---|---|---|---|---|---|---|
| | | Set 0 | Set 1 | Set 2 | Set 3 | Set 4 |
| 90 | Z | Z | Z | Z | Z | Z |
| 91 | [ | [ | [ | [ | Ø | [ |
| 92 | \ | \ | √ | Ç | Æ | ¡ |
| 93 | ] | ] | ] | ] | ø | ] |
| 94 | | ^ | ↑ | ^ | æ | ^ |
| 95 | _ | ‾ | ‾ | ‾ | ¯ | ¯ |
| 96 | | ` | ` | ` | ` | ` |
| 97 | a | a | a | a | a | a |
| 98 | b | b | b | b | b | b |
| 99 | c | c | c | c | c | c |
| 100 | d | d | d | d | d | d |
| 101 | e | e | e | e | e | e |
| 102 | f | f | f | f | f | f |
| 103 | g | g | g | g | g | g |
| 104 | h | h | h | h | h | h |
| 105 | i | i | i | i | i | i |
| 106 | j | j | j | j | j | j |
| 107 | k | k | k | k | k | k |
| 108 | l | l | l | l | l | l |
| 109 | m | m | m | m | m | m |
| 110 | n | n | n | n | n | n |
| 111 | o | o | o | o | o | o |
| 112 | p | p | p | p | p | p |
| 113 | q | q | q | q | q | q |
| 114 | r | r | r | r | r | r |
| 115 | s | s | s | s | s | s |
| 116 | t | t | t | t | t | t |
| 117 | u | u | u | u | u | u |
| 118 | v | v | v | v | v | v |
| 119 | w | w | w | w | w | w |
| 120 | x | x | x | x | x | x |
| 121 | y | y | y | y | y | y |
| 122 | z | z | z | z | z | z |
| 123 | | { | π | ¨ | ¨ | ~ |
| 124 | | \| | ⊢ | ° | ° | ~ |
| 125 | | } | → | ¨ | ¨ | ~ |
| 126 | ~ | ~ | ~ | ˙ | ° | ~ |
| 127 | DEL | Error 4 Generated | | | | |

# Subject Index

## e (Continued)



## f



## g



## h



## i



## l



## m



## n



## o

## O (Continued)



## P



## R



## S

**S** (Continued)



## t



## u



## v



## w



## x



## y

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