



# PLOTTER NOTES

NUMBER 5

## USING THE HP 7580A DRAFTING PLOTTER WITH YOUR COMPUTER

### A Technical Overview

Successful connection of a computer and peripheral devices from different vendors to form a working system requires that the computer and peripherals be compatible in several ways. Mechanical aspects, electrical signals, communication protocol, and data format must all be compatible. Over the years, standards which apply to these areas have been defined. Computer firms commonly manufacture devices to fit one of these standards. Fortunately, the 7580A drafting plotter, while one of the most advanced products of its kind available today, is also one of the most flexible products available in terms of its ability to be used with a wide variety of computers and systems. This note will be especially helpful to the computer professional who has responsibility for evaluating the requirements of interfacing the 7580A to his system. After reading this overview you will know whether the 7580A plotter can be a part of your computer graphics system.

Using the techniques described herein, HP plotters have been successfully used with virtually all popular minicomputers, most microcomputer systems, and many large commercial systems. In addition to HP systems, some common systems on which users have installed HP plotters include all models of DEC PDP-11 computers with DEC RT-11, RSX-11M, RSTS/E and IAS operating systems, or with the Bell Labs UNIX operating system; the DEC VAX/780 system under VMS; DEC System 10 and System 20 under TOPS/10 or TOPS/20; Prime 300 through 700 systems; SEL 32XX series; Harris; Data General Nova and Eclipse series; Honeywell 6000 series, and Univac systems. IBM systems that satisfy the ASCII data format requirements established in this document, or those equipped with IBM 3277 terminals with the Graphics RPK attachment for ASCII devices have also used HP plotters.

Subjects included in this overview are:

- Choosing the Right Interface — HP-IB or RS-232-C,
- Mechanical, electrical, and data-format compatibility in an RS-232-C environment,
- Handshaking methods and the device control instructions of the 7580A,
- The plotter's instruction set — the Hewlett-Packard Graphics Language (HP-GL), and
- Application programming using HP-GL or HP-ISPP.

### Choosing the Right Interface

The HP 7580A can be interfaced to your computer using one of two standardized interfaces: the HP-IB (Hewlett-Packard Interface Bus) which conforms to IEEE 488-1978 and is sometimes known as GPIB, or the RS-232-C serial interface. In Europe the standardized serial interface is called the CCITT V.24 interface. For the purposes of interfacing an HP plotter, the two serial standards may be considered identical and in this overview all references to RS-232-C apply equally to CCITT V.24. The choice of the "right" interface is determined by which interface is available on your computer system and by the proximity of the plotter to the computer.

### HP-IB Interface

The HP-IB interface offers the advantages of high speed and built-in data-handshake methods. The user does not need to be concerned about handshake requirements to establish communication protocol. The devices are simply plugged together using special cables, and each peripheral is assigned a separate identifying



address using switches on its rear panel. Up to 15 devices may be connected to each HP-IB interface. Data is sent to an addressed device using a familiar program output statement (e.g., in FORTRAN, a "WRITE" statement). The interface takes care of all data handshake protocol. The cable characteristics and high data-transfer speed, however, require there be no more than 2 metres of cable per device and a maximum of 20 metres (65 feet) of cable in the system.

If your computer utilizes the HP-IB interface and you plan to use it to interface your plotter, you need not concern yourself further with interface compatibility or handshake methods. The Hewlett-Packard Interface Bus is totally consistent with all electrical and functional specifications of the IEEE 488-1978 and ANSI MC1.1 standards. The 7580A and nearly all other HP plotters support HP-IB.

If you are still concerned about using the HP 7580A in a HP-IB environment, Chapter 10 and Appendix A of the Hewlett-Packard 7580A Drafting Plotter Operating and Programming Manual (P/N 07580-90000) should answer any remaining questions you may have on 7580A plotter operation. If your concerns are about the interface itself, the Tutorial Description of the Hewlett-Packard Interface Bus (P/N 5952-0156) will be helpful. To obtain these documents, contact your local HP sales and support office.

### *RS-232-C Interface*

The EIA RS-232-C interface is a serial interface that can directly connect devices up to 15 metres (50 feet)\* apart. For longer distances, a modem and dial-up or leased telephone connection may be used. The RS-232-C interface generally requires a separate computer port or connection for each device.

Although the data transmission speeds are much slower in a serial interface, many times data is sent faster than the plotter is able to use it. The user must define and implement a data handshake method to prevent loss of data. In many systems RS-232-C will be the only interface available on the system. Although generally considered a "standard" interface, the wide range of devices and device capabilities available require an understanding of data communication processes and handshake protocol. There are four requirements for successful interface of a plotter and computer when using an RS-232-C interface. They are:

- Mechanical compatibility of the interface connectors,
- Electrical compatibility of the interface signal lines,
- Data-format compatibility between the computer and plotter, and
- a reliable data handshake method.

## **Compatibility in an RS-232-C Environment**

### *RS-232-C Mechanical Compatibility*

Fortunately, the mechanical compatibility is simple. The connectors described in the EIA RS-232-C standard are provided by almost all computer system vendors. Any differences such as male versus female connectors are easily corrected by the use of a short adapter cable. In the RS-232-C standard, connectors with pins are called male connectors.

The HP 7580A when equipped with the (optional) RS-232-C interface provides a compatible 25-pin female connector on the rear panel. The connector is wired to conform to the EIA RS-232-C specifications for DATA TERMINAL EQUIPMENT.

### *RS-232-C Electrical Compatibility*

Electrical compatibility refers to the voltages used to represent the logic signals. In this area, too, the 7580A rigidly adheres to the EIA RS-232-C standard. As with all electrical devices, care should be taken not to install the plotter using long cables in an electronically "noisy" environment. Examples of "noisy" environments are areas containing large machinery or high voltage cables.

### *Data Format Compatibility*

The third area of compatibility required when connecting devices is the data format. As you may know, information is passed between parts of a computer system, in our case between plotter and computer, using electrical signals. On all digital computers these signals represent data bits that are either "on" (1) or "off" (0). Bits are strung together in groups of eight called "bytes". Bytes are strung together to make "words". There has to be an agreement between your computer and plotter as to what a particular sequence of "on" and "off" bits in a bit string will mean. Standard data formats exist which define each letter, number, and some special characters as a unique sequence of bits. Using one of these standard formats, peripherals can talk with computers.

All HP plotters use the ASCII data format. ASCII uses 128 unique 7-bit strings to represent characters

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\*This is normally the maximum direct connect distance recommended by most manufacturers. Actually the maximum distance is a function of the data communication rate, the cable type and the cable environment. Some unconditioned cables have been successfully run at 2400 bits per second over 4 kilometres (2.5 miles).



found on a typewriter keyboard and some additional "control characters" which are found on many terminal keyboards. The eighth bit is generally reserved for parity or error checking purposes. Just as alphabetic characters are strung together by people to make words, and the words combined to make a language, plotters use ASCII characters to form words and a language all their own. This language is the plotter's instruction set which will be discussed later in this document.

## Handshake Methods

The last requirement for successful operation of the 7580A with a computer in an RS-232-C environment is a suitable handshake. In most applications, the plotter will receive data faster than it can process it. A 1024-byte buffer is available in the plotter to temporarily store the excess. In order to avoid overflowing the buffer and losing data, some type of data handshake method must be used. Four different types of data handshake methods can be used with the HP 7580A: a software handshake controlled from the application program, a computer-controlled handshake managed by the communication interface or operating system, a plotter-controlled "Xon/Xoff" handshake, and a plotter-controlled hardware handshake. The handshake chosen is dictated by what the computer system can do and the communication efficiency required by the intended application.

## Device Control Instructions

The application software must send to the plotter the instructions necessary to establish the desired handshake. This is accomplished using device control instructions which are in addition to the HP-GL instruction set discussed later in this overview. The Device Control Instructions are shown in the appendix. Only two of the eleven device control instructions may be used in an HP-IB environment.

If you have more questions on handshaking, ask your HP representative for the RS-232-C Interfacing/Handshaking Guide (P/N 5953-4085) for a complete description of the RS-232-C interface and a methodology by which you can determine what is available on your computer.

## The Plotter's Instruction Set, HP-GL

The HP 7580A and nearly all other HP plotters use the Hewlett-Packard Graphics Language (HP-GL) as their language (instruction set).

## HP-GL

The HP 7580A instruction set includes 60 HP-GL instructions, which tell the plotter what it is to do:

draw a line, select a pen, establish a specified height for characters, etc. Each instruction consists of two ASCII characters, which are a mnemonic or abbreviation that helps you remember the instruction's function. This makes HP-GL easy to learn and remember. For example, the instruction to select a pen is SP. Most instructions are followed by parameters which represent such things as coordinate data, text of a label, or size of characters. Instructions are usually delimited by a semi-colon. The flexible format requirements of HP-GL and the large number of powerful instructions make this language easy to use in nearly any application program. The commands are listed in the appendix. The HP 7580A Operating and Programming Manual referenced earlier describes the use of the HP 7580A HP-GL instruction set in detail. Use of HP-GL is discussed further in the next section.

## Application Programming

An application program can control a plotter directly using the HP-GL instruction set, or it can control it indirectly by using graphics programming tools such as high level utilities or BASIC language extensions that in turn send HP-GL commands to control the plotter. Higher-level graphics software is available on all HP computers; most of this software includes support for the 7580A.

The Hewlett-Packard Industry Standard Plotting Package (HP-ISPP) is a utility that consists of 13 user-callable FORTRAN subroutines. It is used to make existing programs compatible with HP plotters and for new programs in engineering applications. Decision Support Graphics for HP 3000 computers (DSG-3000) is a complete graphics program used to create a variety of line, bar, and pie charts. Graphics/1000-II is an interactive design-oriented graphics package for the HP 1000 computer. Graphics extensions of the BASIC language exist for desktop and personal computers. All this software uses HP-GL to control HP plotters. Other utility programs for the plotter, available from third party sources, include DISSPLA and DI-3000.\*

Graphics applications programs to accomplish specific tasks also exist. DSG/3000, DSG/250, and the Graphics Presentations Pacs for desktop and personal computers are graphics application programs available from Hewlett-Packard. TELL-A-GRAF\*, from a third-party source, is a graphics application program which can be used with HP plotters. Only HP-GL and HP-ISPP will be described here.

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\*DISSPLA and TELL-A-GRAF are products of Integrated Software Systems Corporation. DI-3000 is a product of Precision Visuals Inc.



## *Programming in HP-GL*

Regardless of the programming language used (FORTRAN, BASIC, PASCAL, COBOL, FORTH, C, micro-assemblers, etc.), if your computer can, using WRITE, PRINT, etc., send all 96 ASCII printing characters plus the characters "ESC" and "ETX" in any arbitrary sequence to a peripheral, it can control an HP plotter using HP-GL. A few computers may require use of decimal, octal, or hexadecimal equivalents (of the ASCII characters which are the mnemonics and parameters of HP-GL commands) in the WRITE or PRINT statements, but the result is still the same. All that matters is that the proper sequence of "on" and "off" bits to represent ASCII characters be sent to the plotter.

For example, with the FORTRAN unit number 10 assigned to the physical device designation for your plotter, the following program will label "Plotting" beginning at the point X=1000, Y=2000 plotter units.

```
PROGRAM PLOT
LBTERM = 3
WRITE(10,40) LBTERM
40  FORMAT ('PA1000,2000;LBPlotting',1A2)
STOP
END
```

(Note: The program is for a 16-bit computer. For a 32-bit computer, 1A2 should be replaced by 1A4.)

In these examples PA and LB are the HP-GL "Plot Absolute" and "Label" instructions respectively. See the appendix for a complete list of HP-GL instructions.

## *Programming Using HP-ISPP*

HP-ISPP (model no. 17580A) is a set of subroutines very similar to the CalComp basic plotting software. The package is written in FORTRAN, and is easily installed on any ASCII-based computer that offers a FORTRAN programming language compatible with the requirements of ANSI FORTRAN X3.9-1966. It allows any existing FORTRAN application program that uses the CalComp basic plotting software to drive

a non-HP device to instead drive a HP plotter without major program modification. The program need only be re-compiled with the HP-ISPP library instead of the corresponding subroutines in the CalComp library. HP-ISPP supports the whole HP plotter family of HP-IB and RS-232-C devices.

You may also use HP-ISPP for any new applications, particularly on small computer systems where program space is limited. It takes care of all data formatting and handshake protocol, data array scaling and axis drawing functions, and provides access to all HP-GL commands for special needs. It makes programming even easier than in HP-GL alone because most HP-ISPP routines send several HP-GL instructions to the plotter.

HP-ISPP is available on 9-track magnetic tape, prepared in densities of either 800 or 1600 bits per inch, or on flexible diskette for DEC RX-01 disc drives. The system-dependent characteristics such as word size, character format, and data handshake methods are specified at installation time through simple numeric variable assignments in a single subroutine. In most cases, installation can be accomplished within a few hours. Many non-ASCII (e.g., EBCDIC-based) systems can use HP-ISPP software with the addition of suitable user-developed character-conversion subroutines. The system must be able to send at least all 96 printing ASCII characters and the control characters "ESC" and "ETX" in any arbitrary sequence to the plotter.

Refer to the HP-ISPP data sheet (5953-4086) for the list of subroutines and an example program. For additional information refer to the Hewlett-Packard Industry Standard Plotting Package User's Manual (P/N 17580-90002) and the HP Industry Standard Plotting Package Installation Guide (P/N 17580-90003).

## **Summary**

The power and flexibility of the HP 7580A, the convenience of HP-GL and the simplicity of HP-ISPP software all combine to offer you the highest possible plotter performance available today — on any computer system. Call your Hewlett-Packard sales representative for additional assistance.



# Appendix A

## HP-GL Instruction Set

Instruction	Definition
<b>Vector Group</b>	
AA X,Y, arc angle (, chord tolerance)	Are absolute X,Y (i); arc angle, chord tolerance (d)
AR X,Y, arc angle (, chord tolerance)	Arc relative X,Y (i); arc angle, chord tolerance (d)
CI radius (, chord tolerance)	Circle radius (i); chord tolerance (d)
PA X,Y(X,Y( . . . ))	Plot absolute (i)
PD (X,Y( . . . ))	Pen down (i)
PR X,Y(X,Y( . . . ))	Plot relative (i)
PU (X,Y( . . . ))	Pen up (i)
<b>Character Group</b>	
BL c . . . c	Buffer label (c)
CA n	Designate alternate character set n (i)
CC chord angle	Character chord angle (d)
CP spaces, lines	Character plot (d)
CS m	Designate standard character set m (i)
DI run, rise	Absolute direction of label (d)
DR run, rise	Relative direction of label (d)
DT c	Define label terminator (c)
ES width(, height)	Extra width between characters and height between lines (d)
IC c	Input character c for sizing via subsequent OB instruction (c)
LB c . . . c	Label ASCII string (c)
LO n	Label origin n (i)
OB	Output box dimensions of character previously input via IC (d return)
OL	Output label buffer length (d return)
PB	Print label buffer
SA	Select alternate character set
SI width, height	Absolute character size (d)
SL tan $\theta$	Absolute character slant from vertical (d)
SR width, height	Relative character size (d)
SS	Select standard character set
UC (pen,)X,Y, pen(, . . . )	User defined character (i)
<b>Line Type Group</b>	
AS a(, n)	Select acceleration a for pen n (i)
FS f(, n)	Select tip force f for pen n (i)
LT t(, l)	Designate line type t (i) and length l (d)
SM c	Symbol mode (c)
SP n	Select pen n (i)
VS v(, n)	Select velocity v for pen n (i)
<b>Digitize Group</b>	
DC	Digitize clear
DP	Digitize point
OD	Output digitized point and pen status (i return)
(c) = ASCII character (d) = decimal format (i) = integer format	



## HP-GL Instruction Set (Continued)

Instruction	Definition
<b>Axes Group</b>	
TL tp, tn	Tick length (d)
XT	X-axis tick
YT	Y-axis tick
<b>Configuration and Status Group</b>	
AP n	Automatic pen operations (i)
CT n	Set chord tolerance mode (i)
DF	Set default values
IM e(, s(, p))	Input e, s, and p masks (i)
IN	Initialize
IP P1 <sub>x</sub> ,P1 <sub>y</sub> (,P2 <sub>x</sub> ,P2 <sub>y</sub> )	Input P1 and P2 (i)
IW X <sub>1</sub> ,Y <sub>1</sub> ,X <sub>2</sub> ,Y <sub>2</sub>	Input window (i)
NR	Enter View state
OA	Output actual position and pen status (i return)
OC	Output commanded position and pen status (i return)
OE	Output error (i return)
OF	Output factors (i return)
OH	Output hard clip limits (i return)
OI	Output 5-character identification (c return)
OO	Output options (i return)
OP	Output P1 and P2 (i return)
OS	Output status (i return)
OT	Output carousel type and pen map (i return)
RO n	Rotate coordinate system (i)
SC X <sub>min</sub> ,X <sub>max</sub> ,Y <sub>min</sub> ,Y <sub>max</sub>	User unit scaling (i)
(c) = ASCII character (d) = decimal format (i) = integer format	



## Device Control Instructions

Device control instructions are three-character escape code sequences comprised of "ESC" and "." followed by one more character. The following syntax conventions are used in the descriptions of device control commands.

- [ ] Brackets indicate that all parameters enclosed are optional.
- ( ) Parentheses indicate that each individual parameter is optional.
- ; The semicolon follows and delimits parameters.
- : The colon terminates any command which may have parameters.
- <DEC> This number represents its decimal value.
- <ASC> This number is the decimal equivalent of an ASCII character.
- ... Specifies a number of optional parameters.
- [TERM] This is the terminator of plotter responses, and is a carriage return unless changed by an ESC.M command.
- ESC** Anything in reverse type represents a single ASCII character.

### Set Plotter Configuration

**ESC**.@ [ (<DEC>); (<DEC>) ]:

Purpose: Enables or disables hardware handshake mode, which uses the Data Terminal Ready (CD) line.

### Output Buffer Space

**ESC**.B

Purpose: Outputs the number of byte spaces currently available for data in the buffer; 0-1024.

### Output Extended Error

**ESC**.E

Purpose: Outputs a decimal code to identify the type of RS-232-C related error that occurred; 0 or 10-16.

### Set Handshake Mode 1

**ESC**.H [ (<DEC>); (<ASC>); (<ASC>; ... <ASC>)) ]:

Purpose: Establishes parameters for handshake mode 1, used when response to handshake enable character requires ESC.M parameters. Sets block-size or Xoff threshold level, handshake enable character, and handshake response string or Xon trigger character(s).

### Set Handshake Mode 2

**ESC**.I [ (<DEC>); (<ASC>); (<ASC>; ... <ASC>)) ]:

Purpose: Establishes parameters for handshake mode 2, used when response to handshake enable character does not require ESC.M parameters. Sets blocksize or Xoff threshold level, handshake enable character, and handshake response string or Xon trigger character(s).



### Abort Device Control

**ESC** . J

Purpose: Aborts any partially decoded or executed device control instructions including outputs.

### Abort Graphic Instruction

**ESC** . K

Purpose: Aborts any partially decoded HP-GL instruction and discards instructions in buffer.

### Output Buffer Size

**ESC** . L

Purpose: Outputs the buffer size as specified by ESC . @ or default 1024 bytes.

### Set Output Mode

**ESC** . M [ (<DEC>) ; (<ASC>) ; (<ASC>) ; (<ASC> ; (<ASC>)) ]:

Purpose: Sets parameters for output; turnaround delay, output trigger character, echo terminate character, and output terminator(s).

### Set Extended Output and Handshake Mode

**ESC** . N [ (<DEC>) ; (<ASC> ; ... <ASC>)) ]:

Purpose: Establishes extended parameters for any output command; intercharacter delay and immediate response string or Xoff trigger characters.

### Output Extended Status

**ESC** . O

Purpose: Outputs the decimal equivalent value of a 16-bit immediate status word, a value less than 488.

