FLEXIBLE INTERFACING WITH HP-IB

The HP Interface Bus (HP-IB) is an easy-to-use hardware and software interface which permits bidirectional, asynchronous communication between a wide variety of instruments. Up to 15 instruments which have built-in HP-IB capability can be interconnected via a simple one-cable system. The interface system utilizes 16 lines to carry all data and control information between the interconnected devices in a byte-serial fashion. A unique 3-wire handshake technique allows data communication over 8 signal lines to take place at a speed determined by the specific device being addressed (i.e., if not addressed, slower devices will not hamper communication speed). General interface management is handled over the remaining 5 signal lines. Each device connected to the bus can be designated either a TALKER (sends data), LISTENER (receives data), or CONTROLLER (controls functions) due to specific address codes assigned to every bus instrument (see Figure 1). The active controller is then able to communicate with the various instruments on the bus in an extremely flexible manner to provide for data transfer, status checking/interrogation, remote/local control, group triggering, and many other control features.

THE 9825 AS A FRIENDLY CONTROLLER

The Hewlett-Packard 9825A Programmable Calculator and the HP 98034A Interface creates a friendly, easy-to-use controller for HP-IB systems. The 9825 is unique in that it maintains all of the user-oriented features generally associated with programmable calculators, while it incorporates much of the power and speed usually identified with minicomputers. The powerful new HPL language combined with versatile I/O software contained in plug-in Read-Only Memory (ROM) creates a new interface bus command structure which eliminates the frustration previously encountered when programming similar systems. Common names and addresses can be associated with HP-IB commands rather than the complex instructions required with other controllers.

The 98034 Interface contains all of the mechanical, electrical, and functional specifications required by IEEE Standard 488-1975. Instruments which follow the standard can be interconnected in a few minutes, and the system is ready to go to work. The controlling processor, including ROM, which is mounted inside the interface card, provides efficient management of interface bus protocol. Since all of the hardware requirements are taken care of automatically, the user is free to concentrate on the control of bus instruments. The following set of interface functions contained in the IEEE Standard will completely describe the 98034 specifications:.

SH1	- source handshake
AH1	- acceptor handshake
T5	- talker
L3	- listener
SR1	- service request
RLØ	- remote local
PP2	- parallel pole
DC1	- device clear
DTØ	- device trigger
C1,2,3,4,5	- controller

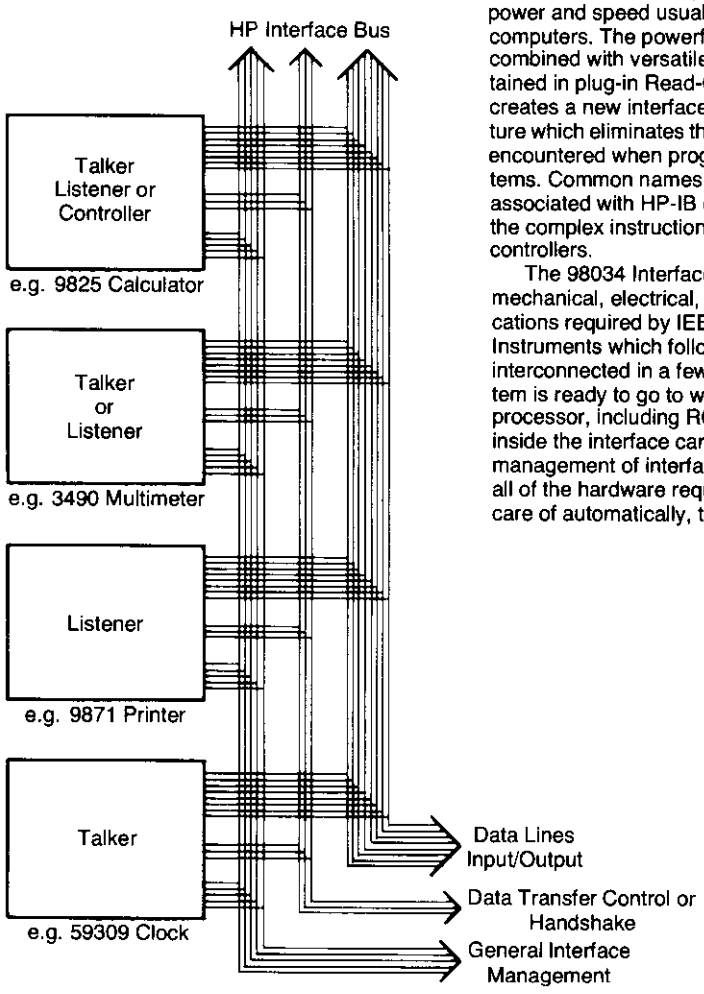

Figure 1

HP-IB with the 9825 Calculator

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hp museum

SIMPLIFIED OPERATION

The General I/O and Extended I/O ROM's provide the capability required to make the HP-IB truly operational in the 9825. With the General I/O ROM, the bus handshake and management lines are controlled automatically. Simplified control is maintained via 3- or 4-digit select codes assigned to various instruments on the bus. Only one address code is required with each item on the bus.

For example, suppose you want to write two variables (A and B) onto the HP 9871A Printer with address code 01. A select code of 7 is normally set on the 98304 interface. The following command will write A and B onto device 01 on bus 7:

```
          bus device
wrt       701,     A,     B
```

If you wish to read data into variables A and B from a HP 3490A Digital Multimeter with address code 22 on the same bus, the following command applies:

```
red     722, A, B
```

The General I/O ROM also contains commands for formatting data, number conversion, reading device status, and reading or writing binary information on the interface bus.

ADDITIONAL CAPABILITIES

The Extended I/O ROM provides many additional capabilities for complete HP-IB control. The command structure is such that HP-IB programming can be made even more transparent or invisible to the programmer. User-defined names can be equated directly to peripheral devices and setup functions, while the interface bus can be addressed directly and information can be easily transferred between peripherals, with the 9825 acting as the monitor.

Using the 9871 and 3490 as in the previous example, you could assign actual names to the HP-IB devices by using the device statement.

```
      name    address   name    address
dev "printer",   701,   "DVM",    722
```

You can also assign names to setup functions necessary for device operation. For instance, the following character sequence is required to set DC volts, range, trigger, and mode on the 3490:

```
DC Volts   10V Range
   FØ          R4
Immediate Internal Trigger
                T1
Addressed Single Output Mode     Execute
          M3                       E
```

The program line in the 9825 is simply:

```
      equ   "RANGE", FØR4T1M3E
```

Now when the range is to be set on the 3490, the following statement can command the desired function to take place:

```
          cmd   "DVM", "RANGE"
```

If you want to transfer 1000 bytes of data from the 3490 and print out on the 9871 with the 9825 acting as the monitor, the following transfer statement would be issued:

```
      3490    9871    # of bytes
tfr    722,    701,      1000
```

Everything on the interface bus is addressed in an easy, natural manner. Many more HP-IB commands are also available for such functions as trigger, service request, parallel polls, and serial poll. The Extended I/O ROM also allows for bit manipulation, burst read/write, buffered I/O, and vectored interrupt. Maximum data transfer rates of 55k bytes/sec. are available on the interface bus.

INTERRUPT — COMPUTER SOPHISTICATION

The interrupt feature is especially useful in applications dealing with the interface bus. The user can specify a location in his program to which control should be transferred when a specified peripheral requests interrupt service. Any device on the bus may be enabled to interrupt on a certain condition. When the given condition occurs, the interrupt is acknowledged and logged into memory, the current line is completed, and the program branches to the location previously specified.

For the HP-IB interface, there are a variety of conditions which are capable of initiating an interrupt request. Again, the commands required for the operation are very easy to use. The commands "on interrupt" (oni) and "enable interrupt" (eir) are used to initiate interrupt routines. If a device on the HP-IB (select code 7) is to create an interrupt condition and the program is to branch to a subroutine, "INT", when the interrupt occurs, simply state the following:

```
oni 7, "INT"
```

To enable the interrupt at some point in the program, the following would be output:

```
eir 7
```

The subroutine, "INT", which is branched to would then have a routine to serial poll the devices on the bus to determine which instrument was requesting service, etc.

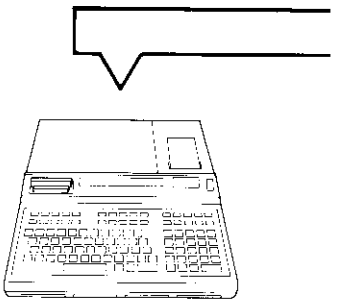
BENEFICIAL USES IN MANY APPLICATIONS

Systems designed around the 9825 can be used in many areas for a wide variety of applications. The block diagram shown in Figure 2 outlines a typical HP Interface Bus configuration. One possible use for this system would be to study temperature variations in a flowing stream or some other body of water near a power plant or factory in order to ascertain certain pollution effects.

The temperatures are measured by thermistors, which output voltages read by the digital multimeter. Various channels of the scanner correspond to individual thermistor or temperature inputs. The 9825 commands the scanner to rotate channels and reads the corresponding voltage equated to temperature from the multimeter. Readings are taken continuously and checked against an established minimum and maximum temperature. If the temperature on any channel falls outside the established limits, the time is read from the clock and the condition is printed on the printer.

A statistical analysis is also performed on the incoming data. A time interval is established for input to the timing generator. The timing generator then interrupts the system at the required intervals. The interrupt routine tells the calculator to store this set of temperature data for future statistical analysis. Although the system is continuously sampling data, only data taken at the timed interval is used for statistical work. At the end of the experiment or upon demand, a plot of temperature vs. time is output on the printer. The 9825 program and the 9871 printer output are shown in Figures 3 and 4.

This example is a very simple demonstration of the power available with HP Interface Bus systems. However, no matter how sophisticated or complicated the system is, the programming simplicity and ease of use available with the 9825 is always the same. Use your imagination and design your own HP-IB system. It's that simple!



```
0: dim A[3:9,3],L[3:9],S[
1: dev "PRINT",701,"PACER
2: ent "IS 9871A READY:0=
3: wtb "PRINT",32,32,27,4
4: wtb "PRINT",27,70,int(
5: wtb "PRINT",27,76,int(
6: ent "ENTER SAMPLE PERI
7: ent "ENTER TIME BETWEE
8: fmt 3,2f3.0,/,3f3.0
9: fmt 2,"T",fz3.0,"E6ASR
10: fmt 1,"C",fz2.0,"E",z
11: 3→A→C;1→P;dim D[int(6
12: 0→A[A,1]→A[A,2];jmp (
13: gsb "time"
14: gto 18
15: "time":fmt 6,f12.0;re
16: 100frc(S/100)→S[A];in
17: ret
18: wrt 16.3,"DATE ",S[5]
19: fmt 6,2/,54x,"Tempera
20: fmt 6,"Channel #
21: wrt "PRINT.6"
22: fmt 6,5x,"Time  Temp.
23: fmt 7,4x,z
24: wrt "PRINT.7";1→A
25: wrt "PRINT.6";jmp (1+
26: fmt 3,/
27: wrt "PRINT.3"
28: wrt "PACER.2",T
29: oni 7,"int";eir 7
30: 3→C;gsb "read"
31: if P<=R;gto -1
32: gto "analysis"
33: "read":wrt "SCAN,1",C
34: fmt 6,f8.0
35: wtb "DVM","R7F1S1T1M3
36: red "DVM.6",V
37: 3807/(ln(V)+9.69)-273
38: if H<L[C] and not flg
39: if flgC and max(L[C],
40: if (C+1→C)<10;gto "re
41: ret
42: "int":wrt "PACER.2",T
43: 3→B
44: L[B]→D[P,B];jmp (B+1→
45: if (P+1→P)>R;dir 7;ir
46: iret
47: "out of bounds":cmf C
48: fmt 4,18x,z
49: fmt 5,2x,3f3.0,f7.2
50: 1→F;wrt "PRINT.7"
51: if C=3;gto +5
52: wrt "PRINT.4";jr  (F+
53: wrt "PRINT.5",S   ,S[
54: "analysis":
*26934
```

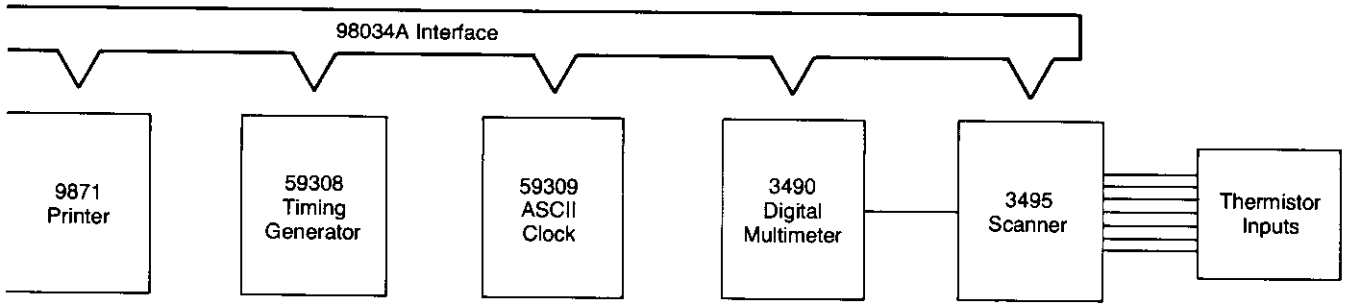
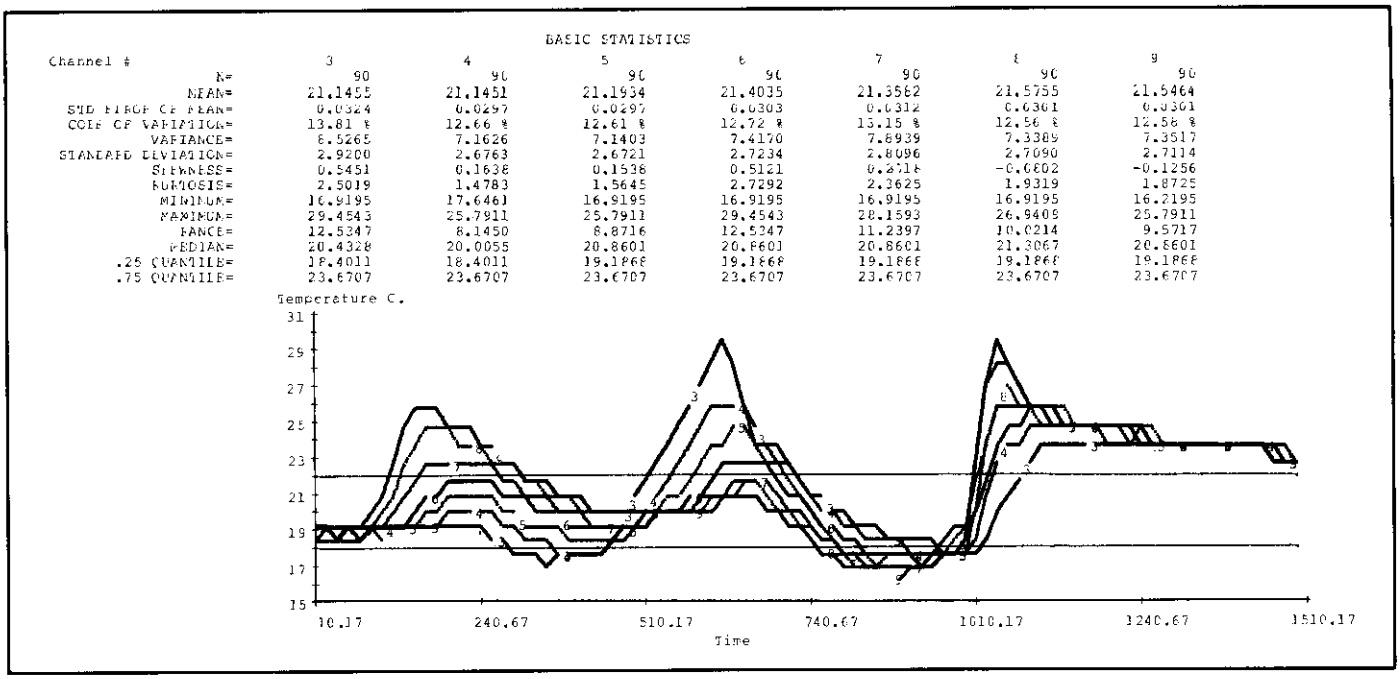


Figure 2

```
;]                                                          } Dimension arrays.
',706,"SCAN",709,"CLOCK",720,"DVM",722                      } Assign names to bus devices.
iO,1=YES",N;if N#1;jmp 0
)                                                           } Sets printer form dimensions.
.056/64),1056
316/64),816
)D IN MINUTES",N                                            } Input sample and interval times.
I SETS IN SEC.",T;jmp T>5 and T<1000
',z                                                         } Formats for printer, pacer, and scanner.
fmt 9,2f,z
)N/T→R)+1,3:9];cfg 3,4,5,6,7,8,9;22→H;18→L                  } Initializes variables and flags.
\+1→A)=10

] "CLOCK,6",S;1→A                                           } Reads 10-digit clock time.
t(S/100)→S;jmp (A+1→A)=6
,"/",S[4],"TIME",S[3],S[2],S[1]                             } Writes on internal printer.
:ure Profile",/;wrt '"PRINT,6"
3",1"  "4",17x,"5",17x,"6",17x,"7",17x,"8",17x,"9"

C",z                                                        } Prints information if temperature exceeds limits.

\→A)=8

                                                            } Sets time interval on pacer.
                                                            } Sets interrupt conditions.
                                                            } Continuously monitors temperature.
                                                            } Statistics routine.

;"

16→L[C];L[C]+A[C,1]→A[C,1];1+A[C,2]→A[C,2]                  } Reads temperature from 7 channels (3-9),
! or L>L[C] and not flgC;gsb "out of bounds"                stores average temperature, and compares limits.
.)=min(H,L[C]);gsb "out of bounds"
d"

)=10                                                        } Interrupt routine -
t                                                           Saves current temperatures for plots.

gsb "time"                                                  } If temperture exceeds limits, prints time and
                                                            temperature on printer.
→F)^-3
1,S   ,L[C];ret                                             } Prints statistical information.
                                                            (routine not shown)
```


Figure 3



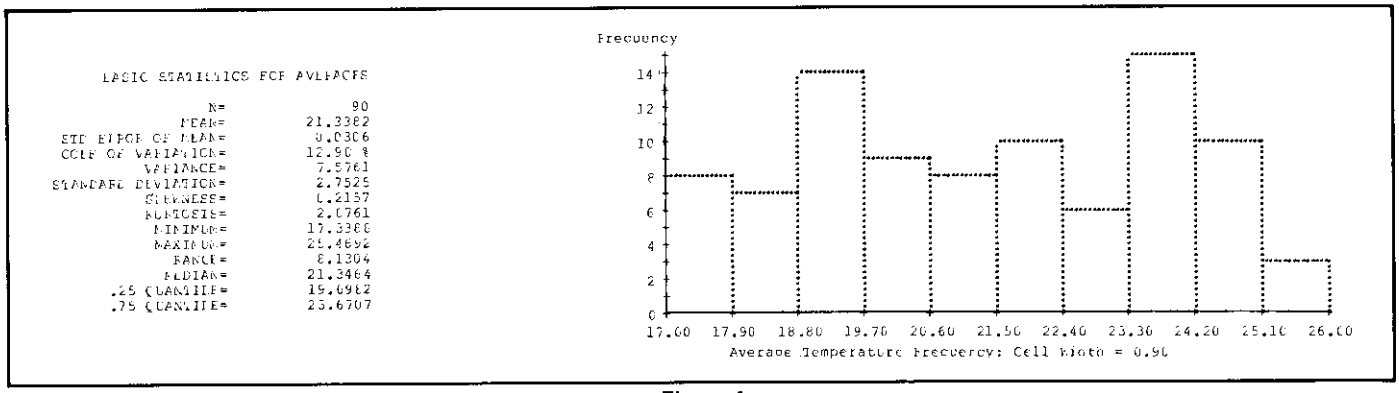


Figure 4

HP-IB COMPATIBLE INSTRUMENTS

The HP-IB is a major instrumentation interface within Hewlett-Packard. It assures maximum interface capability among our products and shows the commitment Hewlett-Packard has made in this area of instrumentation. There are currently many Hewlett-Packard instruments which have the standard HP-IB option:

3320A/B	Synthesizer
3330A/B	Synthesizer
3490A	Digital Multimeter
3495A	Scanner
436A	Digital Power Meter
5328A	Frequency Counter
5341A	Frequency Counter
5345A	Frequency Counter
5300B	Frequency Counter
5150A	Thermal Printer
59301A	ASCII to Parallel Converter
59303A	D to A Converter
59304A	Numeric Display
59306A	Relay Actuator
59307A	VHF Switch
59308A	Timing Generator
59309A	ASCII Digital Clock
59400A	RS-232-TTY Interface
59401A	Bus System Analyzer
59500A	Multiprogrammer Interface
59403A	Common Carrier Interface
8016A	Word Generator
8620C	Microwave Sweep Oscillator
9660A,C	Microwave Synthesizer
9871A	Character Impact Printer

MORE THAN A CONTROLLER

In addition to being an outstanding controller for an HP-IB system, the 9825 also supports a wide variety of peripherals and application software. Peripherals such as graphic plotters, card readers, digitizers, tape readers, and tape punches can be added to aid in computational ease. User-oriented statistical programs dealing with histogramming, regression analysis, test statistics, and distributions are available in prewritten software packages to aid in data handling. The HP solution to your systems needs gives you flexibility, powerful performance, and ease of operation which can save you both time and money.

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