HEWLETT-PACKARD

HP 82938A

HP-IL Interface

OWNER'S MANUAL

SERIES 80

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Series 80

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Section 1

General Information

Introduction

The HP 82938A HP-IL Interface allows you to link your HP Series 80 Personal Computer with a growing family of low power and/or battery operable HP-IL controllers and devices.

This manual describes how to connect and operate your HP-IL interface. For information about the special features of each peripheral device, please refer to the owner's manual for that device. The I/O ROM manual may also contain useful information for more specialized operations.

When the HP-IL interface connects the HP Series 80 Personal Computer to an interface loop, many devices can communicate with each other. Communication over the two-wire loop is asynchronous and serial, with digital messages traveling from one device to the next around the loop in one direction only. All devices must meet certain functional, electrical, and mechanical standards to communicate by means of HP-IL.

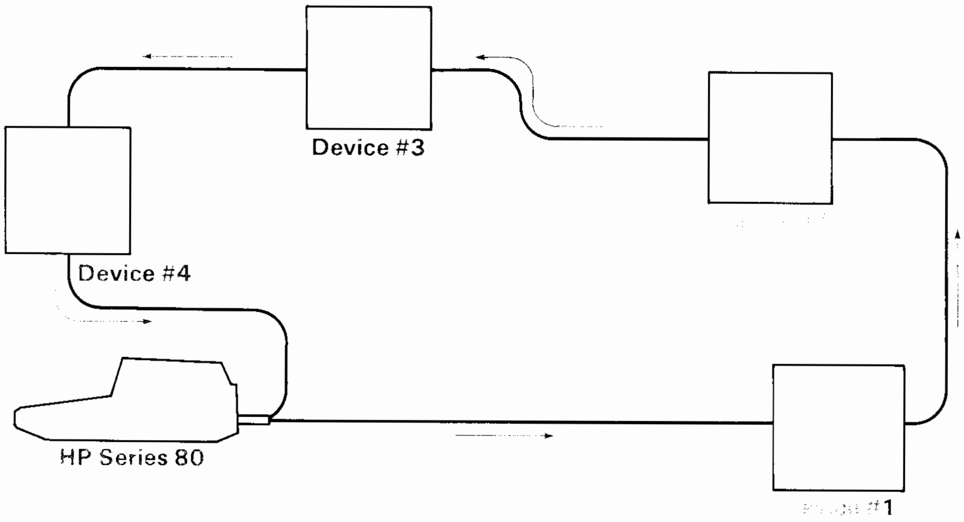


Figure 1-1. Interface Loop Concept

The advantages of this system include small size, low power requirements, low cost, lightweight cabling, and medium distance capability.

External ROMs

The interface requires one of the following ROMs to perform input/output operations. The type of ROM used determines which loop operations can be performed. The available ROMs include:

- I/O ROM (P/N 00085-15003)
- Plotter/Printer ROM (P/N 00085-15002)

The I/O ROM is a general purpose ROM and is used in a wide variety of applications, and the Plotter/Printer ROM simplifies interfacing plotters and printers.

These ROMs fit into a ROM drawer which plugs into any of the four I/O ports on the HP Series 80 Personal Computer. Ensure that you have the proper ROM for your system.

Select Code

The interface select code is used in programming to designate the interface to which output is sent by the computer. The interface select code for the HP-IL interface is preset at the factory to 9. Each interface connected to the computer must have a unique select code. The select code can be changed by resetting switches located on the interface printed-circuit assembly. The procedure for changing the interface select code is covered in section 2 of this manual.

Technical Specifications

Dimensions	16.7 by 12.7 by 1.5 cm (6.59 by 5.0 by 0.59 in.)
Maximum Cable Length	10 meters (33 feet) between devices with standard cable.
Operating Temperature	0° to 55°C (32° to 131°F).
Storage Temperature	−40° to 65°C (−40° to 150°F).
Connectors	Two-pin.
Signal Levels	1.5 Vac.
Power Requirements	The computer mainframe supplies all power for the interface via the I/O ports on the back panel.

Loop Functions

Loop functions provide the capability for a loop device to send, receive, and process messages if the device has the functional capability to do so. Some of the more common functions are listed here.

Handshake—A technique used by devices to synchronize information transfer.

Listener—A device with listen capability that is **listener active**. As such, it is prepared to receive data bytes sent by the **talker active** device.

Talker—A device with a talker capability that is talker active. As such, it is prepared to send data bytes to one or more listener active devices. There can never be more than one device operating as a talker at a given time.

System Controller—At power on, one and only one device on HP-IL assumes the role of **system controller**. The HP Series 80 Personal Computer is configured to be the system controller by a switch on the HP-IL interface printed circuit board. The system controller resets the loop at power on and becomes **controller active**. Also, the system controller may reset the loop and become controller active at any time, even if control has been passed to another loop device.

Controller Active—The controller active device configures the loop for the exchange of data by sending commands that designate one talker and one or more listeners. It can also send commands to cause specific actions to occur within a device, such as trigger and clear. The controller active device may be able to pass control to any other loop device capable of receiving control.

Serial Poll—The controller active device may serially poll another device to obtain its status byte. A device's status byte denotes the device's present status and whether or not it requested service.

Parallel Poll—The controller active device may be able to conduct a parallel poll to obtain a status bit from devices on the loop that are properly configured.

These functions are discussed in the following sections as they apply to the examples.

Section 2

Installation

Unpacking and Inspection

If the shipping carton is damaged, ask the carrier's agent to be present when the interface is unpacked. When you unpack your HP-IL interface, you should also find a one-meter cable with a connector on each end. If the interface or cable is damaged, immediately notify the carrier and the nearest HP sales and service office. Retain the shipping carton for the carrier's inspection. The sales and service office will arrange for the repair or replacement of your interface without waiting for the claim against the carrier to be settled.

Preset Switches

The select code and system controller switches are preset at the factory as follows:

- Select Code **9**.
- System Controller **Enabled**.

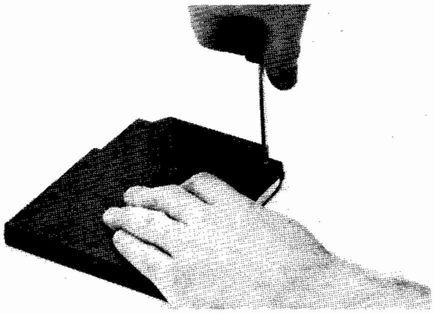
If it is not necessary to change or verify the factory settings, refer directly to Installing the Interface on page 12.

Verifying or changing any of the switch settings requires disassembly of the interface housing. If this is necessary, use the following disassembly procedure.

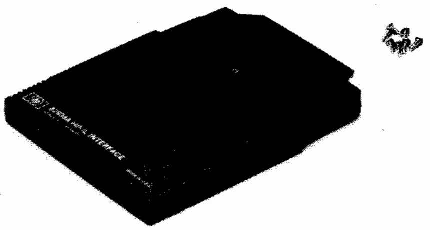
Disassembly

Refer to figure 2-1 to see how the interface parts fit together. Place the interface on a flat surface with the side having the screws facing upward and the cable connectors to the left. Then use the following steps to disassemble the interface.

1. Using a Pozidriv® 1 screwdriver, remove the seven screws and set them aside.



2. Hold the interface parts together and turn the interface over so that the screw holes are facing downward and the cable connectors are still positioned to the left.



3. Remove the top half of the interface housing and rotate the interface ninety degrees counterclockwise.

If you have followed the above steps, the switch bank should be positioned as shown in figure 2-2. If it is not, orient it as illustrated before identifying the switch segments.

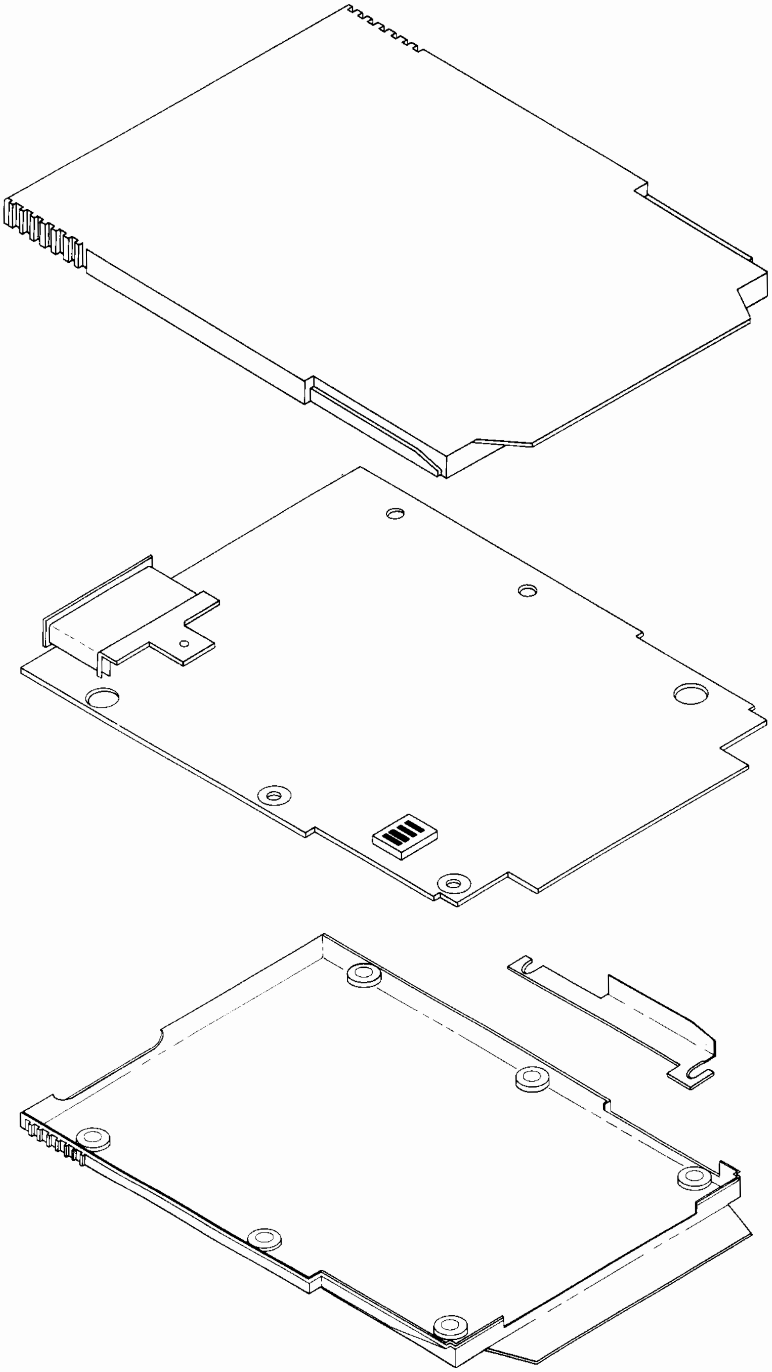
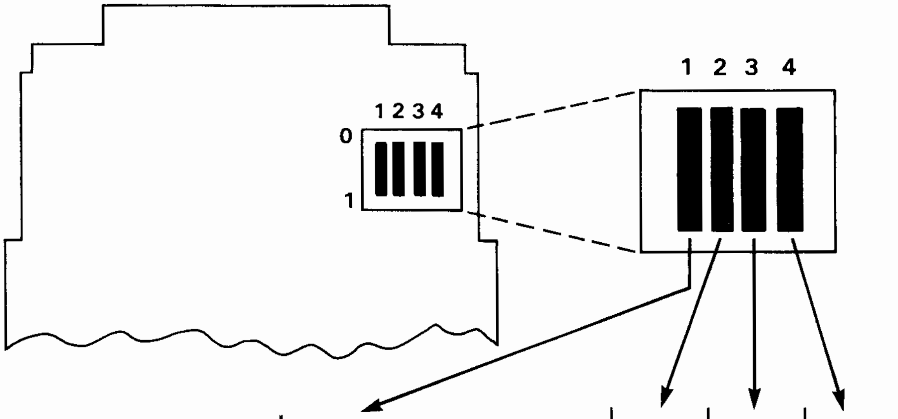


Figure 2-1. Disassembly

When you reassemble the interface, reverse the above procedure, making sure the ground clip is in place. The ground clip should be under the circuit board when the component side is up.

To reset any of the switch segments, refer to figure 2-2. Segments 2, 3, and 4 determine the select code; segment 1 is the system controller enable switch.

> Note: If you change any of the factory settings, make sure that you change the proper switch segments. Do not disturb the settings of adjoining switches. The small tip of a pencil or similar object is recommended for this purpose.



		S1(1)
	Non-System Controller	0
Preset ──►	System Controller	1

	Select Code	S1(2)	S1(3)	S1(4)
	3	0	0	0
	4	0	0	1
	5	0	1	0
	6	0	1	1
	7	1	0	0
	8	1	0	1
Preset ──►	9	1	1	0
	10	1	1	1

Figure 2-2. Switch Settings

Select Code Switch

Select codes 3 through 10 may be set with the switch segments. To change or verify the factory setting, orient the circuit board as shown and locate switch segments 2, 3, and 4. Now identify the **0** and **1** switch positions on the circuit board. You may verify that the select code "9" is properly set by comparing the actual positions of switch segments 2, 3, and 4 with those illustrated. They should be the same.

To change the select code, refer to the table and set switch segments 2, 3, and 4 as required for the select code chosen. For example, if select code "3" is to be set, the three switch segments must all be set to **0**.

Remember that each interface must have a different select code. Improper operation will result if more than one device is set to the same select code.

System Controller Switch

The system controller takes control of the loop at power on and reset. Switch segment 1 of the switch bank is preset to **1** at the factory to enable the HP Series 80 Personal Computer as system controller. During loop operation the system controller may pass control of the loop to another device capable of control, but one and only one HP-IL device can assume system controller status.

If the computer is to be the system controller, leave switch segment 1 in the factory preset position. To verify the factory setting, orient the circuit board as shown in figure 2-2 and locate switch segment 1. Now identify the **0** and **1** switch positions on the printed circuit board. Switch segment 1 should be in the **1** position as illustrated.

If the computer is not to be the system controller, set switch segment 1 to the **0** position. It is important that one and only one loop device be assigned as system controller. Failure to comply with this requirement will result in improper loop operation and/or Error Message 118.

Installing t[illegible]

Before you start the installation process you should read through and understand this entire section.

CAUTION

Always turn off the computer and any connected peripherals before installing or removing the interface. The interface or computer could be damaged if this procedure is not followed.

The following steps should be performed in order:

1. Set the power switch located on the back of the computer to the OFF position.
2. Turn off any peripherals already connected to the computer by a previously installed interface.
3. Remove the protective cover from any one of the unused ports on the back of the computer, keeping the remaining ports covered. You do not need to remove any previously installed plug-in modules.
4. Line up the interface module with the port and gently slide the module into the port opening. When you feel a small amount of resistance, firmly press the module into the port until the interface grips meet the side of the port. A slight side-to-side motion may be necessary to seat the module in the port.

[illegible]ecting [illegible] Devices

The interface loop consists of your HP Series 80 Personal Computer, the HP-IL interface, and from one to 30 peripheral devices. These should be connected according to the instructions below.

The peripheral devices may be connected to the loop in any order, but all of the interface cables must form a continuous loop. The cable length between any two devices in the loop should not exceed 10 meters (33 feet).

Each HP-IL device is shipped with a compatible cable. These cables will connect to the loop in a way that causes the loop to be formed or maintained. You should not need to force the connectors when the loop is properly configured. Simply connect the cables to the proper connectors to form the interface loop. Each device, including the interface, should have two cables connected to it. *Each device in the loop must be on for the loop to operate properly.*

Disconnecting the Interface Loop

To remove any peripheral device from the interface loop, simply unplug the device from the loop and reconnect the loop where the device was removed.

To remove the HP-IL interface card from the computer, first switch off the computer. Then pull the interface out of the port in the computer and install a port cap on the empty port.

Functional Test

To test the HP 82938A HP-IL Interface:

1. Verify the select code setting of the interface.
2. Verify that the system controller switch is set to the enabled position.
3. Install the HP-IL interface in the computer.
4. Install a ROM drawer with an I/O ROM in the computer.
5. Set the computer power switch to ON.
6. Type the program listed below into your HP Series 80 Personal Computer.
7. Plug one HP-IL cable into both connectors on the back of the interface, forming a closed loop.
8. Press (RUN).

```
10 CLEAR ! HPIL EXERCISER
20 DISP "HPIL EXERCISER","ENTER SELECT CODE";@ PRINT "HPIL EXERCISER"
30 INPUT S
40 IF RIO(S,0)=255 THEN DISP "NO INTERFACE RESPONDS AT THAT","SELECT CODE, TRY A
GAIN" @ GOTO 30
50 DISP "ENTER # TIMES TO RUN TEST";
60 INPUT N
70 SET TIMEOUT S;500
80 ON TIMEOUT S GOTO 890
90 GOSUB 170 ! STATUS TEST
100 GOSUB 400 ! DATA TEST
110 GOSUB 520 ! SRQ INTERRUPT TEST
120 N=N-1
130 IF N>0 THEN GOTO 90
140 DISP "TEST PASSED" @ PRINT "TEST PASSED"
150 OFF TIMEOUT S
160 STOP
170 DISP "STATUS TEST"
180 DIM B(8)
190 RESET S
200 WAIT 500 ! GIVE CONTROLLER TIME TO CONFIGURE LOOP
210 IF RIO(S,1)#3 THEN GOTO 670 ! RESET ERROR
220 FOR I=1 TO 8
230 B(I)=FNS(I-1) ! READ ALL STATUS REGISTERS
240 NEXT I
250 F=0
260 IF B(1)#5 OR B(2)#0 OR B(7)#0 OR B(3)>7 THEN F=1
270 IF B(6)=0 THEN GOSUB 700 @ GOTO 290 ! CHECK IF CONTROLLER
280 IF B(6)#96 THEN GOTO 320 ELSE GOSUB 680 ! LOOP ERROR
290 IF B(8)#0 OR BIT(B(5),5) OR BIT(B(5),6) THEN F=1
300 IF F THEN GOTO 720
310 GOTO 1120 ! NONCONTROLLER OR LOOP PROBLEM
320 ! AT THIS POINT INTERFACE IS CONTROLLER AND LOOP IS CONFIGURED
330 IF B(3)#4 OR B(5)#128 OR B(8)>31 THEN F=1
340 IF B(6)#32 AND B(6)#40 THEN F=1
350 IF B(4)#0 OR B(8)>31 THEN F=1
360 IF B(8)<32 THEN DISP B(8);"LOOP DEVICES RECOGNIZED"
```

```
370 IF F THEN GOTO 720
380 RETURN
390 !
400 DISP "DATA TEST"
410 SEND S ; MLA
420 FOR J=0 TO 17
430 I=INT(2^(J-10))+(J<9)*(255-INT(2^(J-1)))
440 ! SEND 255,254,253,251,247,239,223,191,127,0,1,2,4,8,16,32,64,128
450 CONTROL S,2 ; 0,I@ WAIT 5 ! SEND A DATA BYTE
460 X=FNS(2) @ Y=FNS(3)
470 IF X#0 AND X#1 THEN GOTO 770 ! WRONG FRAME
480 IF Y#I THEN GOTO 790 ! WRONG DATA RECEIVED
490 NEXT J
500 RETURN
510 !
520 DISP "TESTING SRQ INTERRUPT"
530 F=0
540 ENABLE INTR S;8 ! SRQ INTERRUPT
550 ON INTR S GOTO 630
560 CONTROL S,5 ; 1 ! ENABLE ASYNCHRONOUS REQUEST
570 ON TIMER# 1,30 GOTO 600
580 F=1 @ CONTROL S,2 ; 7,170 ! SEND IDY 170 WITH SRQ
590 GOTO 590 ! LOOP UNTIL SOMETHING HAPPENS
600 OFF INTR S @ OFF TIMER# 1 ! INTR DID NOT OCCUR
610 GOTO 810 ! NO INTR
620 !
630 OFF INTR S @ OFF TIMER# 1 ! IDY RCVD
640 IF NOT F THEN GOTO 830 ! INTR TOO EARLY
650 RETURN
660 !
670 PRINT "RESET ERROR" @ GOTO 1130
680 PRINT "LOOP ERROR: CONFIRM CLOSED LOOP","WITH INTERFACE SOLE CONTROLLER"
690 RETURN
700 PRINT "INTERFACE MUST BE CONTROLLER","FOR REMAINING PART OF TEST"
710 RETURN
720 PRINT "STATUS REGISTERS DON'T READ AS","EXPECTED AFTER RESET"
730 FOR I=1 TO 8
740 PRINT "  REG#";I-1;"=";B(I)
750 NEXT I
760 GOTO 1130
770 PRINT "DATA FRAME NOT RECEIVED","OR OVERWRITTEN"
780 GOTO 1130
790 PRINT "INCORRECT DATA RECEIVED","DATA SENT:";I;" DATA RCVD:";Y
800 GOTO 1130
810 PRINT "OPEN LOOP OR INTR. INOPERATIVE"
820 GOTO 1130
830 PRINT "INCORRECT OR SPURIOUS INTR. LOOP","DEVICE MAY BE REQUESTING SERVICE"
840 PRINT "RERUN TEST WITH EMPTY LOOP","TO CONFIRM PROBLEM"
850 GOTO 1120
860 PRINT "IOP HANDSHAKE ERROR"
870 PRINT "EXPECTED RESPONSE";X;" RCVD";Y2
880 GOTO 1130 ! TEST FAIL
890 OFF INTR S @ OFF TIMER# 1 ! INTERFACE TIMEOUT
900 PRINT "*TIMEOUT ON INTERFACE";S
910 GOTO 1130 ! TEST FAIL
920 !
930 DEF FNW(D) = ! WRITE TO XLATOR
940 K=BIT(D,8)
950 WIO S,K;(D MOD 256) @ WAIT 1
960 Y1=RIO(S,0) @ Y2=RIO(S,0) ! RIO AND WIO UNSUPPORTED TEST FUNCTIONS
970 FNW=-5
980 IF Y2#X THEN GOTO 860 ! HANDSHAKE ERROR
990 IF BIT(Y2,0) THEN FNW=RIO(S,1)
1000 FN END
1010 !
1020 DEF FNS(D) = ! STATUS
1030 X=8 @ Z=FNW(1)
1040 Z=RIO(S,1)
1050 Z=FNW(2) ! RIO AND WIO UNSUPPORTED TEST FUNCTIONS
1060 X=11 @ FNS=FNW(256+D)
```

```
1070 X=8 @ Z=FNW(4)
1080 X=0 @ Z=FNW(1)
1090 Z=FNW(0)
1100 FN END
1110 !
1120 PRINT "*TEST ABORT" @ DISP "*TEST ABORT" @ GOTO 1150
1130 PRINT "*TEST FAILED" @ DISP "*TEST FAILED"
1140 BEEP
1150 OFF TIMEOUT S
1160 END
```

Section 3

Simple HP-IL Operations

Concepts

The Hewlett-Packard Interface Loop is easy to use and understand. The HP Series 80 Personal Computer and all devices included in the interface loop are connected together in series, forming a communications circuit. Any information that is transferred among HP-IL devices is passed from one device to the next around the circuit. If the information is not intended for a particular device, the device passes the information on to the next device in the loop. When the information reaches the proper device, that device responds as directed. In this way, the computer can send information to and receive information from each device in the loop, according to the devices capability.

The transfer of information on the loop is analogous to communication among people. Obviously, in any transfer of information between two people, one person must send information while the other receives it. If the information is transferred orally, then the sender is a **talker**, and the receiving person is a **listener**. Similarly, a device sending data on HP-IL is called a talker, and the receiving device functions as a listener. Some devices in the loop can talk and listen (although not simultaneously). A mass storage device such as a disc drive is a talker when it is being read from. It can also function as a listener when being written to.

Some devices are able to function in only one mode, that is, either as talker or listener. A printer, for example, functions solely as a listener.

In a group of two or more people, confusion will result if more than one person talks at once. A moderator prevents confusion in a group by designating one and only one person to talk at a time. In HP-IL the **active controller** maintains order by assigning a device as the **active talker**. Other functions of the active controller include passing the loop control to another device and designating which devices are **active listeners**. Your HP Series 80 Personal Computer is a device that can function as active controller. The computer also has the capability to be a talker or a listener. It is permissible for several devices to be active listeners simultaneously, but there can only be one active controller and one active talker at any time.

Any device in the interface loop that is not an active controller, talker, or listener must nevertheless be switched on to receive and retransmit instructions and data around the loop.

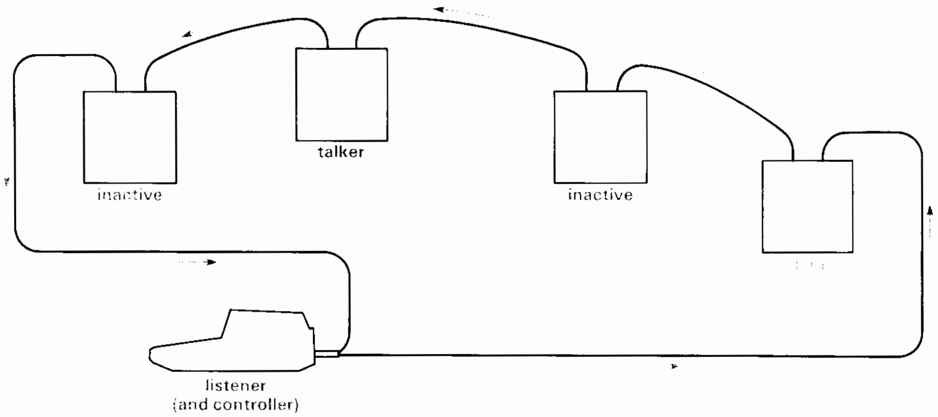


Figure 3-1. Hewlett-Packard Interface Loop

Device Addresses

In order to distinguish among devices in the loop, each device must have an address—a number from 0 to 30. The **system controller** assumes the **0** address at power on, and then assigns addresses starting with **1** for the device next in order after the controller in the direction of information transfer. Each device in the loop stores its unique address internally.

Figure 3-2 shows how you can determine the direction of information transfer by noting the differences in the plugs on the HP-IL cables. It may be helpful to remember that information flows out of the interface through the big connector, around the loop, and back in to the interface through the small connector. These connectors are labeled **IN** and **OUT** as shown in the figure.

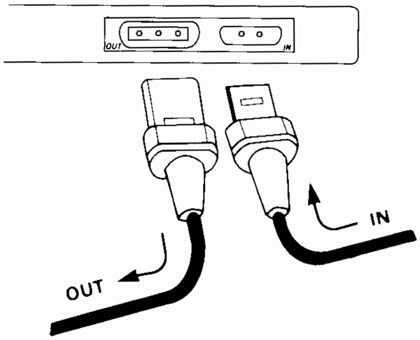


Figure 3-2. Connectors

Printer Operations

Figure 3-3 shows an HP Series 80 Personal Computer (with the I/O ROM and/or a plotter ROM) connected with the HP-IL interface to a loop containing a compatible printer (for example, the HP 82162A). The computer is the system controller and becomes the active controller of the loop when the power is switched on.

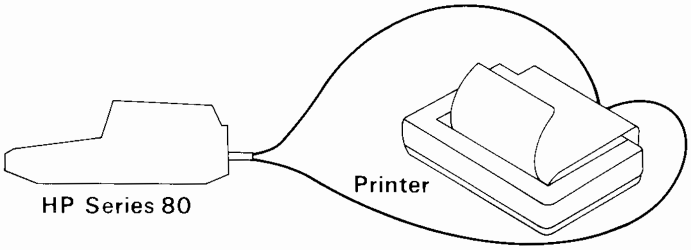


Figure 3-3. Printer Connection

The `PRINTER IS` statement enables you to designate the peripheral printer in the loop as the system printer. With an interface select code of 9 and the printer as the first device in the loop, the statement:

```
PRINTER IS 901
```

select code

device address

directs all printer output through the HP-IL interface to the connected printer.

If your printer is designed to print a line length other than 32 characters, you can modify the output to fit the printer. The Plotter/Printer ROM (HP-83/85) allows the optional line length parameter to select paper width formatting for the device. The line length defaults to 32, but can be set to any integer value from 1 to 140. The statement below designates the second device in the loop as the printer and a line length of 80 characters per line.

```
PRINTER IS 902, 80
```

To change the line length using the I/O ROM, you can use the `OUTPUT USING` or `PRINT USING` statement with an appropriate string specifier. The following statements are an example for an eighty-column printer.

```
10 DIM A$[80]
20 A$="Enlarge the space of your
 tent and stretch out the curtai
ns of your dwelling."
30 OUTPUT 901 USING "80A" ; A$
40 END
```

The procedure is similar for other output devices. If this information is sufficient to make your device work, then you can skip the remainder of this manual. However, if you have more complex needs, or if you wish to know more of the capabilities of the HP-IL interface, then read on.

> **Note:** For any loop operation other than printing or plotting, you should use the I/O ROM. The information in the rest of this manual applies to HP Series 80 Personal Computer systems that incorporate the I/O ROM.

Terminating I/O Operations

In case of problems such as keyboard lockup or abnormal device operation, you should know how to abort an ongoing I/O operation. If the computer keyboard still responds, you can use:

```
ABORTIO 9
```

or

```
HALT 9
```

to terminate or suspend operations.

When the keyboard does not respond, you can sometimes press RESET to regain control of the computer. If the computer responds, the HP-IL interface will be reset also. When none of these procedures causes the computer to respond, you can switch off the power to the computer. Of course, any program stored in memory will be lost in this case. It may also be necessary to switch off other devices on the loop.

Sending and Receiving on the Loop

There are several methods that can be used to send data over the loop. If the interface is active controller, then addressing of the listeners on the loop must be performed. If the interface is not controller, it will wait to be addressed to talk before sending data. For active controller applications the `OUTPUT` or `TRANSFER` statement usually includes at least one listen address. The address is 901 in these two examples:

```
OUTPUT 901; "this is data"
```

or

```
TRANSFER B$ TO 901 INTR
```

You should refer to your I/O ROM manual for a detailed explanation of any unfamiliar I/O commands.

A digital voltmeter such as the HP 3468A can be connected to the loop containing the printer and computer as shown in figure 3-4. The voltmeter typically functions as a **talker**.

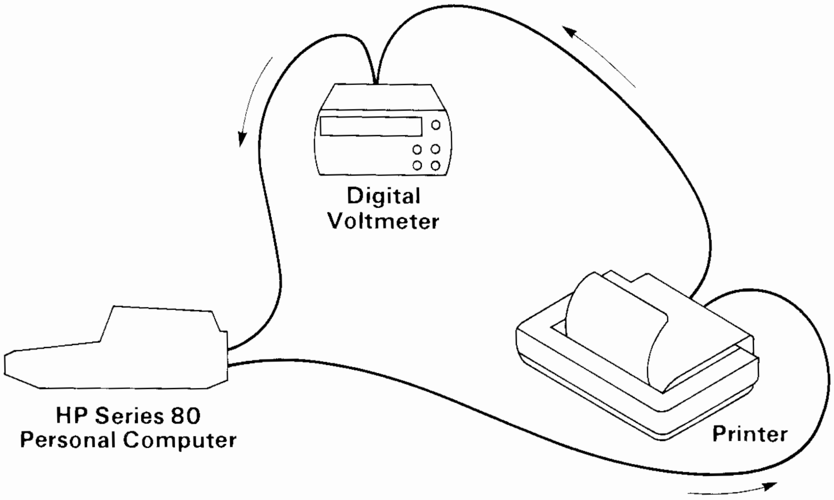


Figure 3-4. Typical Loop

In the loop shown, the voltmeter's address is 902. With the power to all devices switched on, the voltmeter (a talker) can be commanded to send data to the computer (a listener).

To display a voltage reading on the computer CRT, you can use:

```
10 REMOTE 9
20 OUTPUT 902 ; "F1RAT1" ! command voltmeter to take dc
volt readings
30 ENTER 902 ; A
40 DISP "Voltage =";A;"volts"
50 END
```

RUN

To print the value simultaneously on the loop printer (also a listener), add the statement:

```
35 OUTPUT 901 ; A
```

For repeated operation use a `FOR-NEXT` loop:

```
10 REMOTE 9
20 OUTPUT 902 ; "F1RAT1" ! command voltmeter to take dc
volt readings
25 FOR I=1 TO 10000
30 ENTER 902 ; A
35 OUTPUT 901 ; A
40 DISP "Voltage =";A;"volts"
45 NEXT I
50 END
```

The `SEND` command can be used to cause the voltmeter to send data to the printer continuously.

```
10 SEND 9; LISTEN 1 TALK 2
20 RESUME 9
30 END
```

Now press RUN and PAUSE and SCRATCH the program. In this case you can operate the computer in calculator or program mode while data is being sent around the loop, as long as you do not address the HP-IL interface. Thus, data can be sent and recorded while the computer is used in an unrelated application. To halt loop operations, use:

```
HALT 9
```

Non-Controller Applications

Certain device configurations may necessitate that some device other than the computer (with HP-IL interface) be **controller active**. For example, if you need to transfer data from an HP-41C Calculator to your computer, you will need the HP 82160A HP-IL Module. By itself, this module always causes the calculator to assume the role of **system controller**. Since the loop will not work properly unless one and only one device is system controller, the HP-IL interface must be reconfigured. Refer to section 2 for the procedures needed to reset the system controller switch to off.

For this example, we simply connect the calculator and computer together in a loop. The calculator (system controller) is the active controller when power to the two devices is switched on.

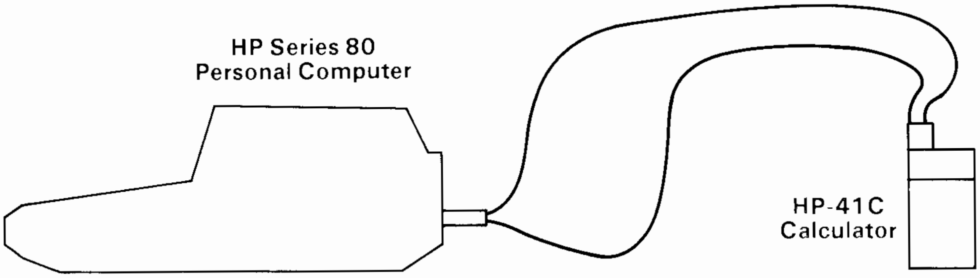


Figure 3-5. Computer-Calculator Connection

The HP 82938A HP-IL Interface will not automatically assume the **listener** function; a program must be running that awaits data from the loop. The following program causes the computer to receive data from the loop.

```
10 CLEAR
20 DISP "WAITING"
30 ENTER 9 ; A$
40 DISP A$
50 END
```

If you now enter the words *TOTALLY COMPATIBLE* into the ALPHA register of the HP-41C, you can use the OUTA function in the HP-IL Module to send the data string to the loop. The computer will then receive it and store it as the string A$. If you output a string that is longer than 18 characters and A$ has not been dimensioned using the `DIM` statement, the computer will only save the first 18 characters.

To send data from the computer to the calculator, enter and run the following program:

```
10 DIM Z$[20]
20 Z$="HI FROM HP SERIES 80"
30 OUTPUT 9; Z$
40 END
```

Then execute AUTOIO and INA on the calculator; you should find the string in the ALPHA register.

Notice that when the computer is not controller active, only the select code is specified. Device addresses are used by the active controller.

Printing Calculator Programs

If the computer in your loop is the HP-85, you can use the internal printer to print your calculator programs by running the program listed below.

```
10 CLEAR
20 DISP "WAITING..."
30 ENTER 9 ; A$  ! Receive data from loop.
35 ! Print and display program line.
40 PRINT A$
50 DISP A$
55 ! Check for end of program
60 IF POS(A$,"END") THEN 80
70 GOTO 30
75 ! Display DONE if END encountered.
80 ENTER 9 USING "#,#B" ; A
90 DISP "DONE"
100 END
```

To print a calculator program, you must execute AUTOIO, MANIO, SELECT with 1 in the X-register, and PRP ***name***. You should then see the program listed on the HP-85 internal printer.

Calculator Data Transfer

Suppose that you have taken ten data measurements with the HP-41C Calculator at a remote site and stored the values in registers R_{01} through R_{10}. When you return to your office, you desire to transfer this data to your HP Series 80 Personal Computer and store it using HP-IL. The following calculator program will output your data to the loop:

01 LBL^{T}XFER	
02 CF 29	Turns off comma flag.
03 1.010	Set ISG counter 1-10.
04 STO 00	
05 1	Select computer for output.
06 SELECT	
07 LBL 00	
08 CLA	
09 ARCL IND 00	Put first value in ALPHA register.
10 OUTA	Send to computer.
11 ISG 00	Increment counter and test for 10th register.
12 GTO 00	
13 END	Stop.

Now create a data file named "`FILE`" on the mass storage medium (tape or disc):

```
CREATE "FILE",10,10
```

Program the computer with these commands:

```
 10 DIM X(10) ! Ten registers.
 20 ! Open FILE.
 30 ASSIGN# 1 TO "FILE"
 40 FOR I =1 TO 10
 50 ! Input each register value from HP-41C.
 60 ENTER 9 ; X
 70 ! Write register number and value to mass storage.
 80 PRINT# 1 ; I,X
 90 DISP "Register ";I;"is";X ! Display value.
 100 NEXT I
 110 END
```

Run both programs and see the data displayed on the CRT. The data file `"FILE"` should contain the register number and the data for each of the ten measurements.

The stored information can be accessed using the following commands on the computer:

```
 10 ASSIGN# 1 TO "FILE" ! Open FILE.
 20 FOR I = 1 TO 10 ! Ten values to be read.
 30 READ# 1 ; I,X ! Read register number and value.
 40 ! Print each register number and value.
 50 PRINT "Reg. ";I;" = ";X
 60 NEXT I
 70 STOP ! Stop after printing the tenth register.
```

The above examples illustrate some of the fundamentals involved in sending and receiving data via the HP-IL interface. Incorporating these techniques into programs can vastly increase the capabilities of your HP Series 80 Personal Computer.

The next section in this manual contains information useful in more advanced loop operations.

Section 4

Advanced Operations

This section contains information necessary for advanced operations on the Hewlett-Packard Interface Loop. Useful I/O commands are discussed, along with some additional device functions. The examples will give you some idea of the variety of operations that can be performed using the HP-IL interface.

The material in this section is more complex than that contained in the previous sections of this manual. A large amount of information is presented here, with the specific applications and experimentation left to you, the programmer. You may need to refer to the I/O ROM documentation for syntactic information.

Accessing Control and Status Registers

The HP-IL interface can be adapted to meet particular programming needs by accessing the interface control and status registers. The interface has a total of sixteen accessible registers. Some can only be read, some can only be written to, and some are combination read/write registers.

If you have a plotter ROM, the SET I/O statement gives you the ability to write to control registers 1 thru 5 and 16 thru 23. The plotter ROM does not give you the ability to read the interface status registers.

If you have an I/O ROM, you can access the interface control registers with the CONTROL, ASSERT, and ENABLE INTR statements. In addition, the STATUS statement allows you to access status registers 0 thru 7. Refer to the I/O ROM manual for additional information on writing to and reading from registers.

HP-IL Control Registers

A table is given first, followed by explanations of individual registers.

HP-IL Control Registers

Register Number	Bit Number								Default Value	Register Function
	7	6	5	4	3	2	1	0		
CR1	IFC	LA	CA	TA	SRQ	CLR	GET	DDC	0	Interrupt Mask
CR2	X	X	X	X	X	C2	C1	C0	4	Next Control Bits
CR3	D7	D6	D5	D4	D3	D2	D1	D0	N/A	Next Data Byte
CR4	AAD	X	X	A4	A3	A2	A1	A0	N/A	Loop Address
CR5	X	X	X	X	X	X	X	EAR	0	Interface Status

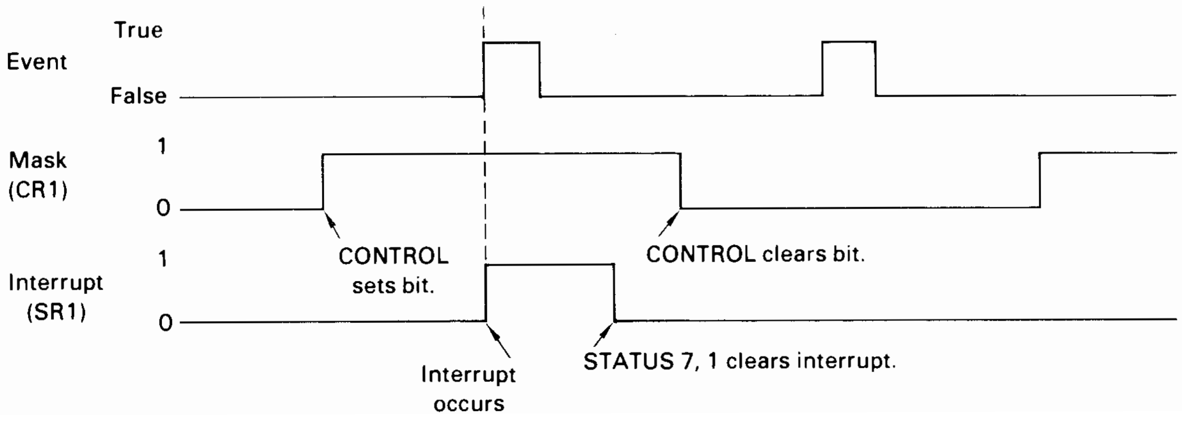
Control Register 1: Interrupt Mask

A bit set high enables the corresponding interrupt condition to cause an end-of-line branch.

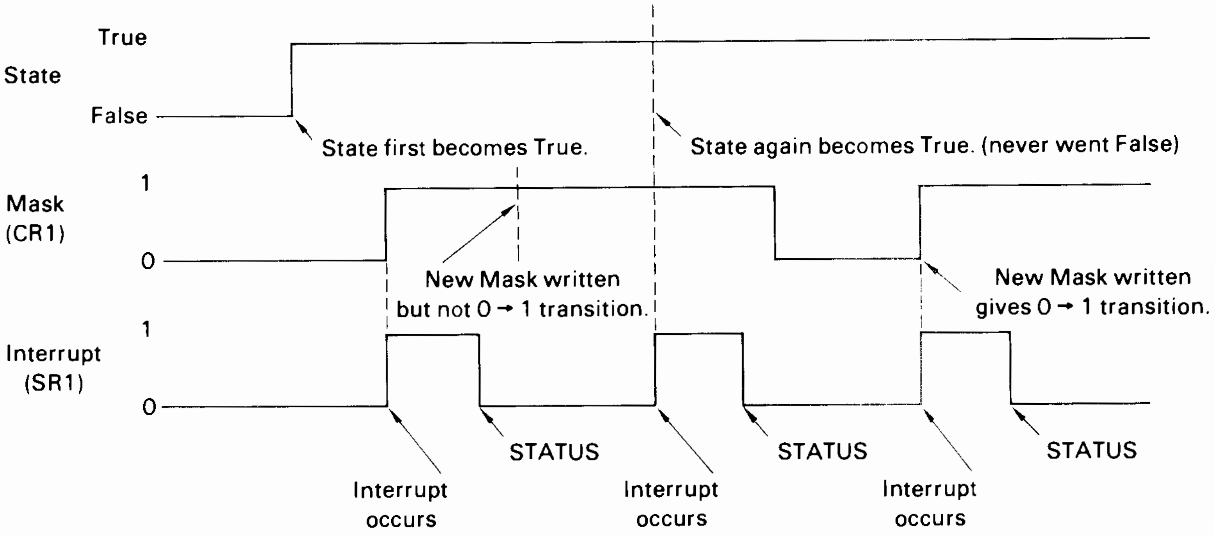
- Bit 0 set enables interrupt when a device dependent command is received. The value of the command that was received is stored in SR6, the device dependent command register. This is an event-initiated interrupt.
- Bit 1 set enables interrupt when the trigger message is received and the interface is addressed to listen. This is an event-initiated interrupt.
- Bit 2 set enables interrupt when the device clear or selected device clear (if listener active) is received. This is an event-initiated interrupt.
- Bit 3 set enables interrupt when SRQ (Service Request) is true.
- Bit 4 set enables interrupt when the interface becomes active talker. If TA is already high, then a "0"-to-"1" transition of bit 4 of CR1 causes an interrupt. This is a state-initiated interrupt.
- Bit 5 set enables interrupt when the interface becomes active controller. If CA is already high, then a "0"-to-"1" transition of bit 5 of CR1 causes an interrupt. This is a state-initiated interrupt.
- Bit 6 set enables interrupt when the interface becomes listener active. If LA is already high, then a "0"-to-"1" transition of bit 6 of CR1 causes an interrupt. This is a state-initiated interrupt.
- Bit 7 set enables interrupt when an IFC (Interface Clear) message occurs. An externally caused IFC can cause an interrupt even when the interface is the system controller. This is an event-initiated interrupt.

The following diagrams illustrate the interface response to state-initiated, event-initiated, and SRQ interrupts. The interrupt-cause status register (SR1) bits are set when interrupts occur and are cleared when the status of SR1 is read.

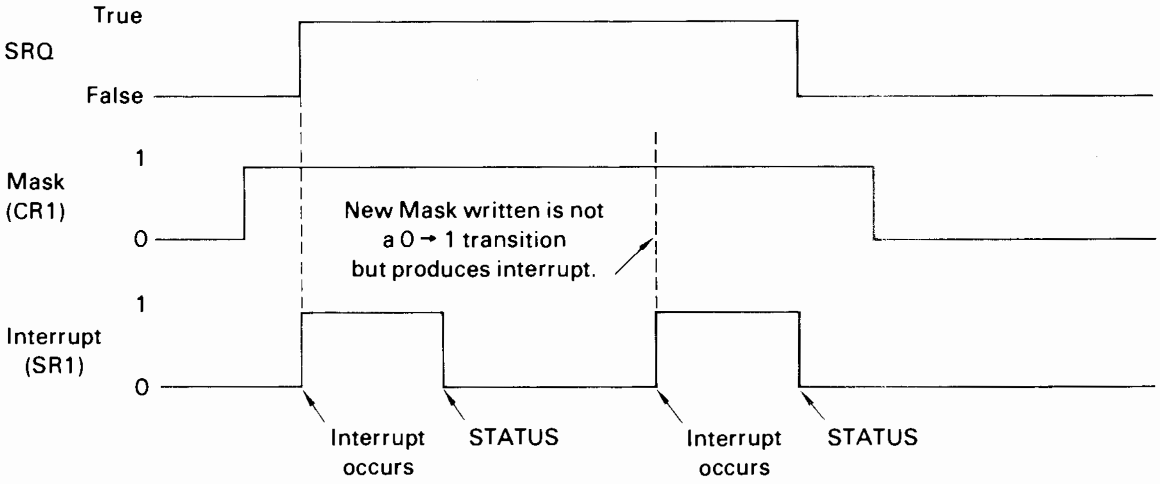
Event-initiated interrupt
(SCG, GET, SDC/DCL, IFC)



State-initiated interrupt
(TA, CA, LA)



SRQ interrupt



CAUTION

Control registers 2 and 3 provide direct access to the HP-IL control and data functions. They must be used with care; it is possible to cause loop malfunctions or device damage by improper use of these registers.

Control Register 2: Loop Control Bits

This register contains the next control bits to be sent. The bits written to this register will be saved for subsequent writes to Register 3. Control bits are assigned according to the following table. Default is 4 (command).

Value	Assignment
0	DATA
1	DATA
2	END
3	END
4	COMMAND
5	READY
6	IDENTIFY
7	IDENTIFY (with service request—SRQ)

Note: SRQ is ignored on data and end messages.

Control Register 3: Data Byte

Writing to this register causes a frame to be sent using the control bits from Register 2. For example, to send a carriage return, `CHR$(13)`, use:

```
10 CONTROL 9,2;0,13 ! Write a zero (data) to Register 2
                    and 13 (CR) to Register 3.
```

The returned frame is available in status registers 2 and 3.

Control Register 4: Loop Address Register

This register contains the address assigned to the interface and an auto address flag. At power on the default value is 31, but when the auto address is sent by the active controller, this value is changed according to its assigned address. If the computer is the active controller, the value changes to 128.

- Bits 0 through 4 indicate the address assigned by the active controller.
- Bit 7 is the auto address flag. It is automatically set when the interface is assigned an address by the active controller and cleared when auto address unconfigure (AAU) is received.

Control Register 5: Asynchronous Service Request Enable/Disable

The interface must be active controller to write to this register. Writing a zero enables the interface to perform repetitive polling of the loop. Writing a one causes the enable asynchronous service requests (EAR) message to be sent and no polling to take place.

End-of-Line Sequence Registers

Control registers CR16 through CR23 provide the user with the capability of customizing the end-of-line output sequence that is sent at the end of a data transfer and with the "/" OUTPUT/PRINT image specifier. Also provided is the capability of automatically sending the End frame with the last character of a data transfer.

The following table shows these registers, and their meanings are explained in the following paragraphs.

HP-IL End-of-Line Sequence Registers

Control Register Number	Bit Number								Default Value	Register Function
	7	6	5	4	3	2	1	0		
CR16	EOI Enable	X	X	X	X	EOL2	EOL1	EOL0	2	EOL Control
CR17	Default value = 13 (Carriage Return)								13	Character 1
CR18	Default value = 10 (Line Feed)								10	Character 2
CR19									0	Character 3
CR20									0	Character 4
CR21									0	Character 5
CR22									0	Character 6
CR23									0	Character 7

Control Register 16: EOL Control

This register controls the end-of-line character sequence that is normally sent after a line of output and for the "/" image specifier.

- Bits 0 through 2 specify the number of characters sent as the EOL (end-of-line) sequence. The default count is 2, which causes 2 characters (CR and LF) in registers CR17 and CR18 to be sent. A count of 0 specifies that no EOL sequence is to be sent.

- Bits 3 through 6 are not used.

- Bit 7 set sends the last byte of a data transfer as an End frame.

Control Registers 17 through 23: EOL Sequence

These registers contain the characters sent as the end-of-line sequence. Default values are a carriage return (decimal 13) for CR17 and a line feed (decimal 10) for CR18.

For example, to achieve double-spaced printing, set the EOL count to 3 and the EOL sequence to CR,LF,LF.

```
CONTROL 9,16;3,13,10,10
```

With the plotter ROM, you can achieve the same result using:

```
SET I/O 9,16,3  ! Threecharacters
SET I/O 9,17,13 ! CR
SET I/O 9,18,10 ! Line feed
SET I/O 9,19,10 ! Line feed
```

HP-IL Status Registers

These registers are read by executing the `STATUS` statement. A complete status register table is given, followed by explanations of the individual registers.

Status Register Number	Bit Number 7	6	5	4	3	2	1	0	Default Value	Register Function
SR0	0	0	0	0	0	1	0	1	5	Interface Identifier
SR1	IFC	LA	CA	TA	SRQ	CLR	GET	DDC	0	Interrupt Cause
SR2	X	X	X	X	X	C2	C1	C0	4	Last Control Bits
SR3	D7	D6	D5	D4	D3	D2	D1	D0	0	Last Loop Byte
SR4	AAD	X	X	A4	A3	A2	A1	A0	N/A	Loop Address
SR5	Tx	LA	CA	TA	SRQ	EAR	REN	LLO	N/A	Interface Status
SR6	X	X	T/L	C4	C3	C2	C1	C0	0	Device Dependent Commands
SR7	X	X	X	A4	A3	A2	A1	A0	0	Responding Devices

Status Register 0: Interface Identification

This register always returns a value of 5, indicating that this is an HP-IL interface.

Status Register 1: Interrupt Cause

A bit set indicates the interrupt condition that caused an end-of-line branch. SR1 is reset to 0 when it is read by a `STATUS` statement.

- Bit 0 when set indicates that a device dependent command was received. The value of the command received is available in SR6. This is an event-initiated interrupt; the interupt, if enabled, will occur when a device dependent command is received.
- Bit 1 when set indicates that a GET (group execute trigger) was received while addressed to listen (LA). This is an event-initiated interrupt; if enabled, the interrupt will occur when the trigger is received.
- Bit 2 when set indicates that either a device clear was received or that a selected device clear (if listener active) was received.
- Bit 3 when set indicates that a service request (SRQ) was received. If interrupts are re-enabled for SRQ and the device continues to request service, then the interrupt will reoccur.
- Bit 4 when set indicates that either (1) the talker active (TA) bit of CR1 underwent a 0-to-1 transition while the interface was addressed to talk, or (2) the interface became addressed to talk while the talker active (TA) bit of CR1 was set. This is a state-enabled interrupt.

- Bit 5 when set indicates that either (1) the controller active (CA) bit of CR1 underwent a 0-to-1 transition while the interface was active controller, or (2) the interface received control while the controller active (CA) bit of CR1 was set. This is a state-enabled interrupt.
- Bit 6 when set indicates that either (1) the listener active (LA) bit of CR1 underwent a 0-to-1 transition while the interface was addressed to listen, or (2) the interface became addressed to listen while the listener active (LA) bit of CR1 was set. This is a state-enabled interrupt.
- Bit 7 when set indicates that an interface clear (IFC) has occurred on the loop. This is an event-initiated interrupt; the interrupt, if enabled, will occur when interface clear is received.

You should refer to the timing diagrams earlier in this section for a better understanding of the interrupt function.

Status Register 2: HP-IL Control Bits

Reading this register yields the last control bit received on the loop. Control bits are assigned as follows:

Value	Assignment
0	DATA
1	DATA (w/SRQ)
2	END
3	END (w/SRQ)
4	COMMAND
5	READY
6	IDENTIFY
7	IDENTIFY (W/SRQ)

Status Register 3: Last Byte on Loop

Reading this register yields the last byte received on the loop as a result of writing to Registers 2 and 3. The control bits in Register 2 determine the type of information that was received.

Status Register 4: Loop Address Register

- Bits 0 through 4 indicate the device address assigned to the interface by the active controller.
- Bit 7, the auto address flag, is automatically set when the interface is assigned an address by the active controller and cleared when auto address unconfigure (AAU) is received.

Status Register 5: Interface Status

- Bit 0, local lockout, is set when the LLO message is received while the interface is listener active.
- Bit 1 is set when the interface is in the remote state.
- Bit 2 is set when the loop has been enabled for asynchronous service requests. If this bit is zero and the interface is active controller, then repetitive identify (IDY) frames are sent on the loop.
- Bit 3 is set when a loop device is requesting service.
- Bit 4 is set if the interface has been addressed to talk and the send data message has been received.
- Bit 5 is set when the interface is active controller.
- Bit 6 is set when the interface is addressed to listen.
- Bit 7 is set when the interface is active controller and the loop has an active data transfer in progress (even if the interface is not involved).

Status Register 6: Device-Dependent Commands

- Bits 0 through 4 constitute a valid device-dependent command if the interrupt bit in Register 1 is set.
- Bit 5 (talker/listener) is set if the command (bits 0 through 4) is a device-dependent listener command and the interface was addressed to listen. Bit 5 clear indicates that it is a device-dependent talker command.

Status Register 7

Reading this register returns the number of devices that responded to the auto address message.

Loop Messages

Devices which communicate along the interface loop are transferring information from one device to another device, or to more than one device. This information can be classified into five types of messages, (data, end, command, ready, and identify).

Data and end messages are used to send data.

The command messages include:

GTL	Go To Local
SDC	Selected Device Clear
GET	Group Execute Trigger
LLO	Local Lockout
DCL	Device Clear
EAR	Enable Asynchronous Requests
IFC	Interface Clear
REN	Remote Enable
NRE	Not Remote Enable
AAU	Auto Address Unconfigure
LPD	Loop Power Down

In addition, the command class contains the address, parallel poll, and device-dependent commands.

The ready messages include:

RFC	Ready For Command
NRD	Not Ready For Data
SDA	Send Data
SST	Send Status
SDI	Send Device Identification
SAI	Send Accessory Identification
TCT	Take Control
ETO	End of Transmission, OK
ETE	End of Transmission, Error

Auto address messages are also in the ready group.

Identify messages are sent by the active controller.

Applications

The remainder of this section contains some examples of the systems and operations possible on the loop. If you are unfamiliar with the I/O commands used, you should refer to your I/O ROM documentation.

Loop Status

The following program uses the `SEND` statement to obtain the status of the interface loop. It reads Register 7 to obtain the number of devices on the loop.

```
10 ! ***********************
20 ! @ LOOP STATUS ROUTINE @
30 ! ***********************
40 S=9 ! Set select code
50 STATUS S,7; S7 ! How many devices?
60 FOR I=1 TO S7
70 SEND S ; UNL MLA TALK I
80 !
90 ! try for accessory id
100 !
110 ON ERROR GOTO 170
120 SEND S ; CMD 254
130 ENTER S USING "B" ; A ! Get single byte accessory ID
140 !
150 ! try for device id
160 !
170 ON ERROR GOTO 210
180 D$=""
190 SEND S ; CMD 255
200 ENTER S ; D$ ! Get the device model number
210 OFF ERROR
220 DISP I;"acc id=";A;"dev id=";D$
230 NEXT I
240 SEND S ; UNL UNT
250 END
```

Depending on the devices connected to the loop, various device and/or accessory identifications will be output. Statements 120 and 190 use CMD 254 and CMD 255. These command messages are peculiar to the HP 82938A HP-IL Interface. CMD 254 causes the accessory identification, a numeric value that describes the capability of the device, to be sent. CMD 255 causes the device identification to be sent. This is a string of characters that represents the model number of the device. (Most devices will respond with at least one of these identifications.)

Using HP-IL for Simultaneous Measurements

The loop system shown below uses three HP 3468A Multimeters (HP-IL) to take one current and two voltage measurements in a circuit.

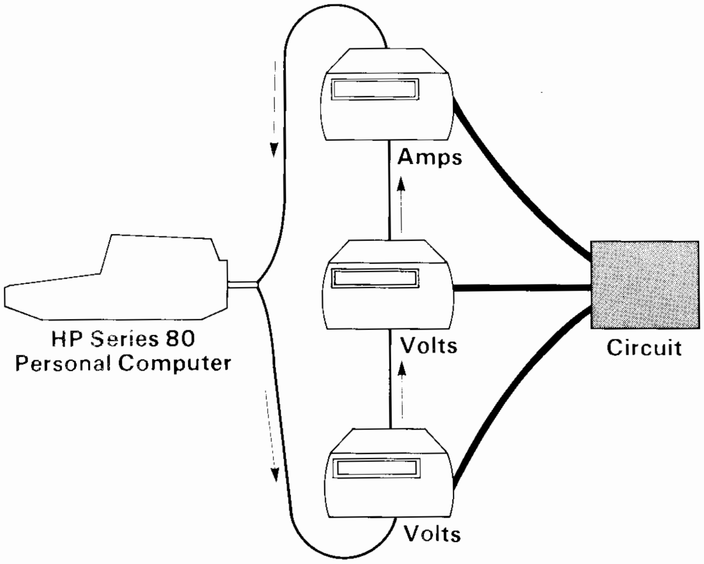


Figure 4-1. Controlling Electrical Measurements

These commands will cause the three measurements to be taken if the devices are enabled for remote operation:

```
10 OUTPUT 901; "F1RAT2" ! Programming string that sets
voltage
20 OUTPUT 902; "F1RAT2" ! and single trigger modes.
30 OUTPUT 903; "F3RAT2" ! Set third meter to measure
current.
40 TRIGGER 901,902,903 ! Trigger the 3 meters
simultaneously.
50 ENTER 901; V1 ! Now enter the readings.
60 ENTER 902; V2
70 ENTER 903; A
80 DISP "V1=";V1,"V2=";V2,"AMPS=";A ! Display readings
90 END
```

Handling Service Requests

Suppose a device on the loop has some problem (printer out of paper, for example). It would be helpful to program the computer to determine which device requires service.

These statements will cause the controller to serially poll the devices on the loop to determine which device sent the service request:

```
1000 S=9 ! HP-IL select code
1010 STATUS S,7; S7 ! Get number of devices
1020 FOR I=1 TO S7
1030 ON ERROR GOTO 1060
1040 Q=SPOLL(S*100+I) ! Poll each device
1050 IF BIT(Q,6) THEN GOTO 1100 ! Did device request
service?
1060 NEXT I
1070 RETURN
1100 DISP "SRQ AT ADR";I
1110 PAUSE
```

For the computer to be alerted that a service request (SRQ) has been sent on the loop, the interrupt capability must be enabled. `ENABLE INTR` sets bit 3 in Control Register 1 to permit this type of interrupt to occur.

```
100 ENABLE INTR 9; 8 ! SRQ interrupt, HP-IL
```

Once an interrupt has occurred, the computer can be directed to go to statement number 1000 with the `ON INTR` command:

```
110 ON INTR 9 GOSUB 1000
```

These sample applications represent only a small portion of the capabilities of HP-IL. For further applications, you should read the documentation accompanying your other HP-IL devices.

HP-IL I/O Statement Summary

The following table summarizes the interface conditions that must be met for a given interface state and program statement, and the resultant actions that are performed.

Table 4-1. HP-IL I/O Messages

Statement	State	Additional Required Conditions	Actions Performed [Command Sequences in Brackets]
`ABORTIO 9`	CA	None	IFC, assumes active control. [IFC]
	Not CA	None	Terminates I/O operation.
`ASSERT 9;X`	Any	None	Immediate write to CR3.
`CLEAR 901`	CA	None	Addressing performed, then sends selected device clear to device 01. [UNL, MTA, LAG, SDC]
`CLEAR 9`	CA	None	No addressing. Send device clear. [DCL]
`CONTROL 9,n;X`	Any	None	Writes X to CRn when interface becomes idle.
`ENABLE INTR 9;X`	Any	None	Writes X to CR1 when interface becomes idle.
`ENTER 905;X`	CA	None	Device 05 is addressed to talk, interface is addressed to listen, data is input to X. [UNL, TAG, SDA]
`ENTER 9;X`	CA	LA	Inputs data to X.
	Not CA	Wait for LA	Waits until addressed to listen, then inputs data to X.
`HALT 9`	CA	None	Terminates I/O operation. [Receives data frame, interjects NRD, retransmits data frame]
`HALT 9`	Not CA	None	Terminates I/O operation. [Sends ETO if Talker Active]
`LOCAL 9`	CA	None	Remote mode is disabled. [NRE]

Table 4-1. HP-IL I/O Messages

Statement	State	Additional Required Conditions	Actions Performed [Command Sequences in Brackets]
LOCAL 901	CA	None	Addressing is performed, then go to local is sent. [UNL, MTA, LAG, GTL]
LOCAL LOCKOUT 9	CA	None	Local lockout is sent. [LLO]
OUTPUT 905;X	CA	None	HP Series 80 device is addressed to talk, device 05 is addressed to listen, data X is sent. [UNL, MTA, LAG]
OUTPUT 9;X	CA	TA	Outputs data X.
	Not CA	Wait for TA	Waits until addressed to talk, then outputs data X.
PASS CONTROL 915	CA	None	Device 15 is addressed to talk, then take control is sent. [UNL, MLA, TAG, UNL, TCT]
PASS CONTROL 9	CA	None	Passes control; no addressing. [UNL, TCT]
PPOLL(9)	CA	None	Sends identify message. [IDY]
REMOTE 9	CA	None	Enables remote operation. [REN]
REMOTE 901	CA	None	Enables remote operation, then device 01 is addressed. [REN, UNL, MTA, LAG]
REQUEST 9;X	Not CA	None	If bit 6 of X is 1, then SRQ is set high. The interface then sends X in response to a serial poll and drops SRQ if set.
RESET 9	SC	None	Sets HP-IL interface to its power-on state. Interface loop is cleared and remote is enabled. [IFC, NRE, REN]
RESET 9	Not SC	None	Sets HP-IL interface to its power-on state.
RESUME 9	CA	No transfer in progress	[SDA]
RESUME 9	CA	Transfer in progress	No messages.
SEND 9;*commands*	CA	None	Sends specified commands.
SEND 9;*data*	Any	TA	Sends specified data.
SPOLL(9)	CA	LA	Conducts a serial poll. [SST, *data,* UNT]
SPOLL(924)	CA	None	Addresses device 24 to talk, then conducts serial poll. [UNL, MLA, TAG, SST,*data,* UNT]

Table 4-1. HP-IL I/O Messages

Statement	State	Additional Required Conditions	Actions Performed [Command Sequences in Brackets]
`STATUS 9,n;X`	Any	None	Sets X to value of SRn.
`TRANSFER` *<out>*	Any	None	Same as OUTPUT.
`TRANSFER` *<in>*	Any	None	Same as ENTER.
`TRIGGER 9`	CA	None	Sends trigger command. [GET]
`TRIGGER 901`	CA	None	Addresses device 01; sends trigger. [UNL, MTA, LAG, GET]

Error Recovery

To ensure that certain errors do not abort a running program (for example, a loop device somehow loses power), you can use a technique similar to the example listed below. This routine checks for error number 118, which could be caused by a data error. The timeout might be caused by an open loop.

```
 10 ON ERROR GOTO 200
 20 SET TIMEOUT 9;5000
 30 ON TIMEOUT 9 GOTO 300
 40 PRINTER IS 901
 50 PRINT "this is it"
 60 DISP "printing..."
 70 GOTO 50
200 ! error trap
210 !
220 IF ERRN=118 AND ERRSC=9 THEN DISP "error 118 in line";
ERRN @ GOTO 330
230 !
240 ! other error handling
250 !
260 GOTO 40
300 ! timeout handler
310 !
320 DISP "HP-IL timeout occurred"
330 RESET 9 @ BEEP
340 GOTO 40
350 END
```

A similar routine is recommended for any program containing I/O operations to increase its reliability.

Section 5

Maintenance, Service, and Warranty

Maintenance

The 82938A HP-IL Interface contains no customer serviceable parts. It should not be necessary to clean the interface module or cable contacts. The action of installing the module into the port and plugging the cable connector into the interface is normally sufficient to clean contamination from the contacts.

The interface does not require regular maintenance. However, the way that you treat it will affect its performance and reliability. Be sure to use it within the operating environment guidelines presented in section 1.

These are some cautionary areas that you should consider:

WARNING

Do not place fingers, tools, or other foreign objects into the plug-in receptacles in the interface or computer. Such actions may result in minor electrical shock hazard and interference with some pacemaker devices. Damage to plug contacts and the computer's circuitry may also result.

CAUTION

Always switch off the computer when inserting or removing the interface or other modules. Use only plug-in modules and cables designed by Hewlett-Packard specifically for the HP Series 80 Personal Computer. Failure to do so could damage the controlling computer or the interface.

Service

If at any time you suspect that the interface is malfunctioning, follow this procedure for isolating the problem:

1. Turn off the computer and all peripherals. Then remove all interface modules and any other plug-in devices from the computer ports. Turn the computer on. If the cursor appears and no error message is displayed, the computer is functioning properly.
2. Turn off the computer and install the interface module in question in any computer port. Install a ROM Drawer with either a plotter ROM or I/O ROM in a second port. Turn on the computer.
   - If `Error 110 : I/O CARD` appears, the interface module requires service.
   - If the cursor does not appear, the system is not operating properly. After turning off the computer, plug the interface into another port. If the system now functions properly, the problem is in the computer port, and the computer requires service.
3. If you have an I/O ROM, you can use the interface test program on pages 13 to 15 in this manual to verify that the interface is operating properly and that you are addressing the interface with the select code to which it has been set.

Warranty Information

The complete warranty statement is included in the information packet shipped with your HP 82938A HP-IL Interface. Additional copies may be obtained from any authorized Hewlett-Packard dealer, or the sales and service office where you purchased your interface.

If you have questions concerning the warranty, and you are unable to contact an authorized HP dealer or HP Sales and Service Office, please contact:

In the U.S.:
One of six Field Repair Centers listed
on the Service Information Sheet packaged
with your owner's documentation.

In Europe:
Hewlett-Packard S.A.
7, rue du Bois-du-lan
P.O. Box
CH-1217 Meyrin 2
Geneva
Switzerland
Tel. (022) 82 70 00

Other Countries:
Hewlett-Packard Intercontinental
3495 Deer Creek Rd.
Palo Alto, California 94304
U.S.A.
Tel. (415) 857-1501

How to Obtain Repair Service

For information on service in your area, contact your nearest authorized HP dealer or the nearest Hewlett-Packard sales and service office.

If your interface malfunctions and repair is required, you can help assure efficient servicing by having the following items with your interface at the time of service:

1. A description of the configuration of the computer and peripheral devices, exactly as they were at the time of malfunction, including any plug-in modules, tape cartridges, flexible discs, and the program and/or ROMs being used.
2. A brief description of the malfunction symptoms for service personnel.
3. Printouts or any other materials that illustrate the problem area.
4. A copy of the sales slip or other proof of purchase to establish the warranty coverage period.

Potential for Radio/Television Interference (For U.S.A. Only)

The HP 82938A HP-IL Interface generates and uses radio frequency energy and may cause interference to radio and television reception. Your HP Series 80 Personal Computer and interface comply with the specifications in Subpart J of Part 15 of the FCC Rules for a Class B computing device. These specifications provide reasonable protection against such interference in a residential installation. However, there is no guarantee that interference will not occur in a particular installation. If your system does cause interference to radio or television reception, which can be determined by turning the computer off and on, you can try to eliminate the interference problem by doing one or more of the following:

- Reorient the receiving antenna.
- Change the position of the computer with respect to the receiver.
- Move the computer away from the receiver.
- Plug the computer into a different outlet so that the computer and the receiver are on different branch circuits.
- Relocate the wires connecting the loop.

If necessary, consult an authorized HP dealer or an experienced radio/television technician for additional suggestions. You may find the following booklet helpful: *How to Identify and Resolve Radio-TV Interference Problems.* This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402, Stock No. 004-000-00345-4.

General Shipping Instructions

Should you ever need to ship the interface, be sure that all components are packed in a protective package (use the original shipping case), to avoid in-transit damage. Hewlett-Packard suggests that the customer always insure shipments.

Appendix A

Theory of Operation

Introduction

This section presents some of the electrical aspects of the HP-IL interface. A complete treatment of the loop functions, operations, and specifications is beyond the scope of this manual. A general description of the circuitry and some operations peculiar to this interface are discussed. Although this information is provided, component level repair is not recommended. If the interface appears to be malfunctioning, you should contact your nearest HP sales and service office for assistance.

The major electrical components in the interface are depicted in this block diagram.

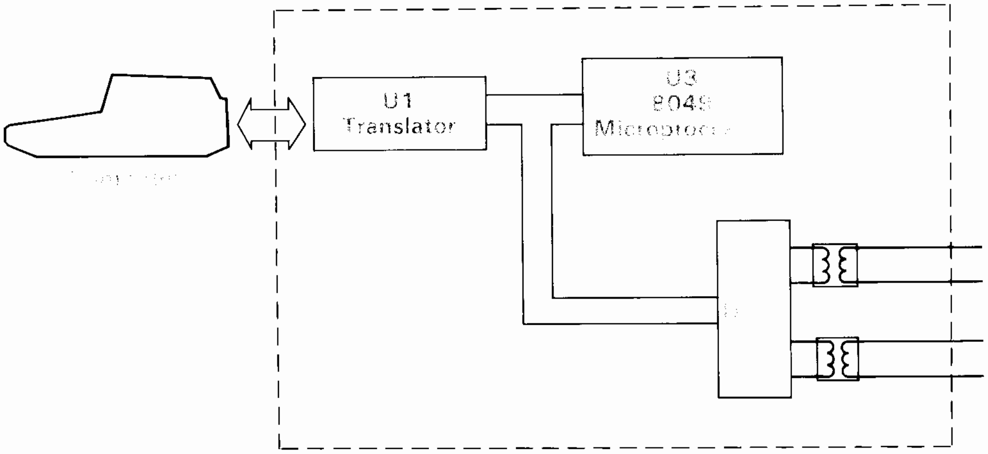


Figure A-1. HP 82938A HP-IL Interface Block Diagram

Translator

The interface uses a microprocessor, which requires the +5V TTL logic level. The microprocessor in the computer uses a +6V logic level. A special IC, U1, known as a translator, permits communication between the two devices by providing level translation. The +5V and +6V power supplies and two +12V clock signals required by the translator are located in the computer mainframe. They are brought to the interface via the I/O backplane when the interface is inserted into one of the four I/O ports.

The translator supports the following operations:

- Handshaking of data and command information between the computer and the interface microprocessor.
- Interrupts issued to the computer by the interface microprocessor.

- Interrupts issued to the interface microprocessor from the computer.
- Fast handshake operation where the translator halts the computer with each data byte transfer to synchronize the flow of data.

The translator contains two buffers. It may be helpful to think of the translator as a mailbox that temporarily holds messages sent between the computer and the microprocessor.

Microprocessor

Microprocessor U3 is the intermediary between the computer and the loop. It implements interface protocol via its ROM. The microprocessor responds to instructions from the host computer or the loop, depending on which loop device is assigned controller status. When the computer is controller active, the microprocessor can recognize a service request from an HP-IL device. If the computer is not controller active, commands from the active controller interrupt the microprocessor. In either of the above cases, depending on user programmed interrupt conditions, it may in turn interrupt the HP Series 80 Personal Computer. Additionally, if the computer is active controller or talker and a frame sent out on the loop is altered, the microprocessor will be interrupted.

The microprocessor serves the dual function of controlling both the computer and the HP-IL IC.

HP-IL IC

Integrated circuit U7 converts signals back and forth from HP-IL to a microprocessor-compatible data bus with appropriate control lines. The microprocessor and the HP-IL IC together form a complete interface between the device and the interface loop. The following list includes some of the significant functions of this component.

- Permits implementing controller, talker, or listener functions or any combination (except talker-listener) simultaneously.
- Messages which the HP-IL IC sends are automatically error-checked when they return and the microprocessor is notified if an error is detected.
- In most cases messages which do not affect the computer are automatically retransmitted without the need for microprocessor intervention.
- All interrupts are fully programmable.
- The HP-IL IC may be set to send service request or respond to parallel poll automatically.

The HP-IL driver and receiver circuitry is isolated from the actual interface lines with pulse transformers and a few discrete components. The IC has an oscillator which requires an external LC network for frequency control. The connection to the microprocessor bus and associated control lines is direct.

The microprocessor communicates with the HP-IL IC through simple memory or read and write cycles. It has a select line and three address lines to permit data transfer to or from eight locations or registers on the IC. In addition to the data transfer, reading or writing certain of the registers causes other actions to take place, such as the transmission of a message over the interface loop. When microprocessor action is necessary, an interrupt line is used.

The HP-IL interface generates a series of tests and messages when the computer is switched on. First, the microprocessor performs a checksum test on program memory (ROM) to verify that it is correct. Then it performs a RAM check by verifying that all internal locations can be written to and read from. After the interface passes these tests, it logs in to the HP Series 80 Personal Computer using an interrupt. Constants are then initialized (for example, the End-of-Line and Control Registers).

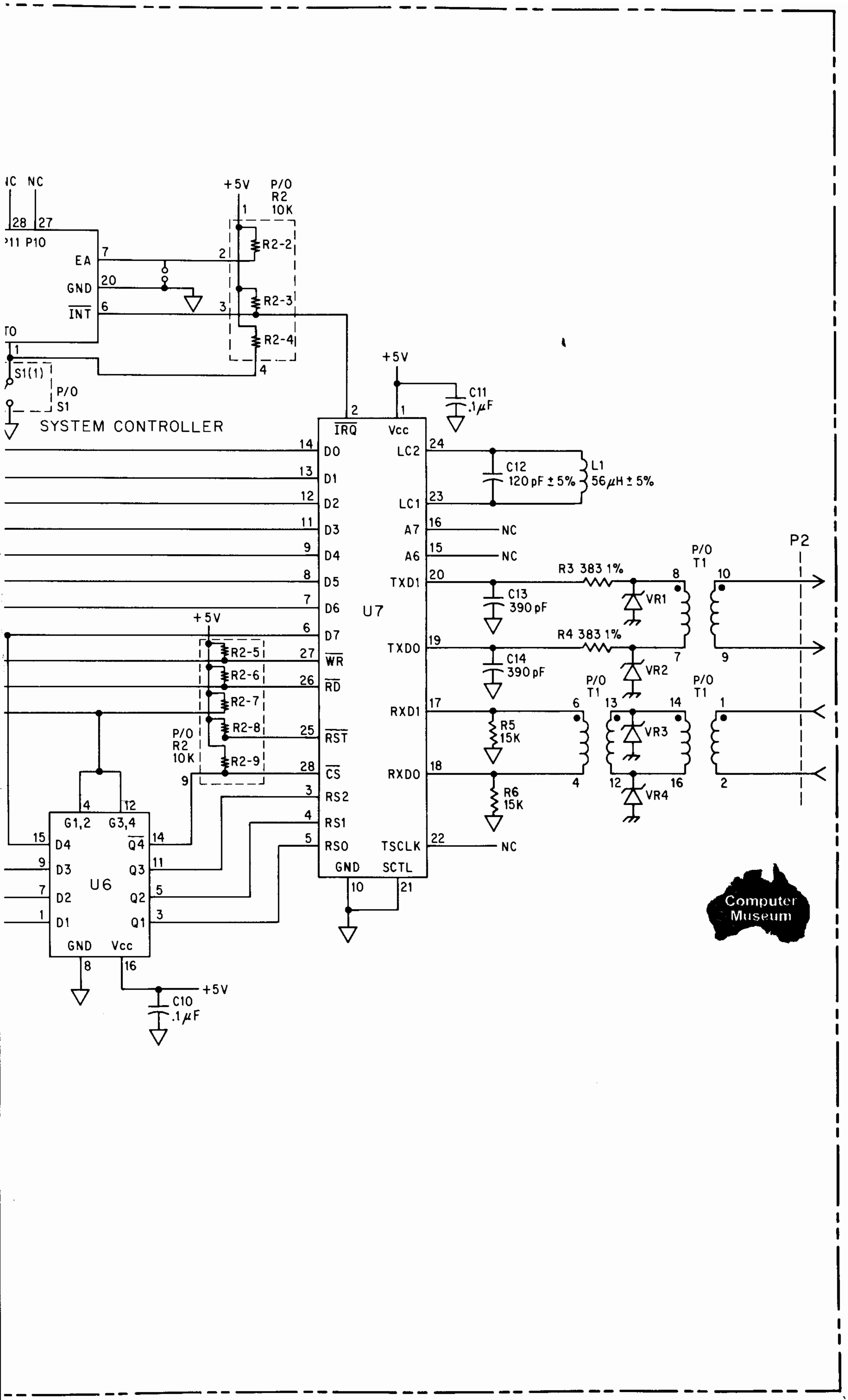
At this point, the system controller switch is read. If the interface is not system controller, it enters an idle state. If it is system controller, an attempt is made to power up the loop by sending IFC continually until one IFC message is returned to the interface. Then one RFC (ready for command) is sent. After the RFC is received back, AAU and AAD messages are sent. After all devices have been assigned addresses, NRE and REN are sent to enable the devices to enter the remote state. Then the interface enters the idle state.

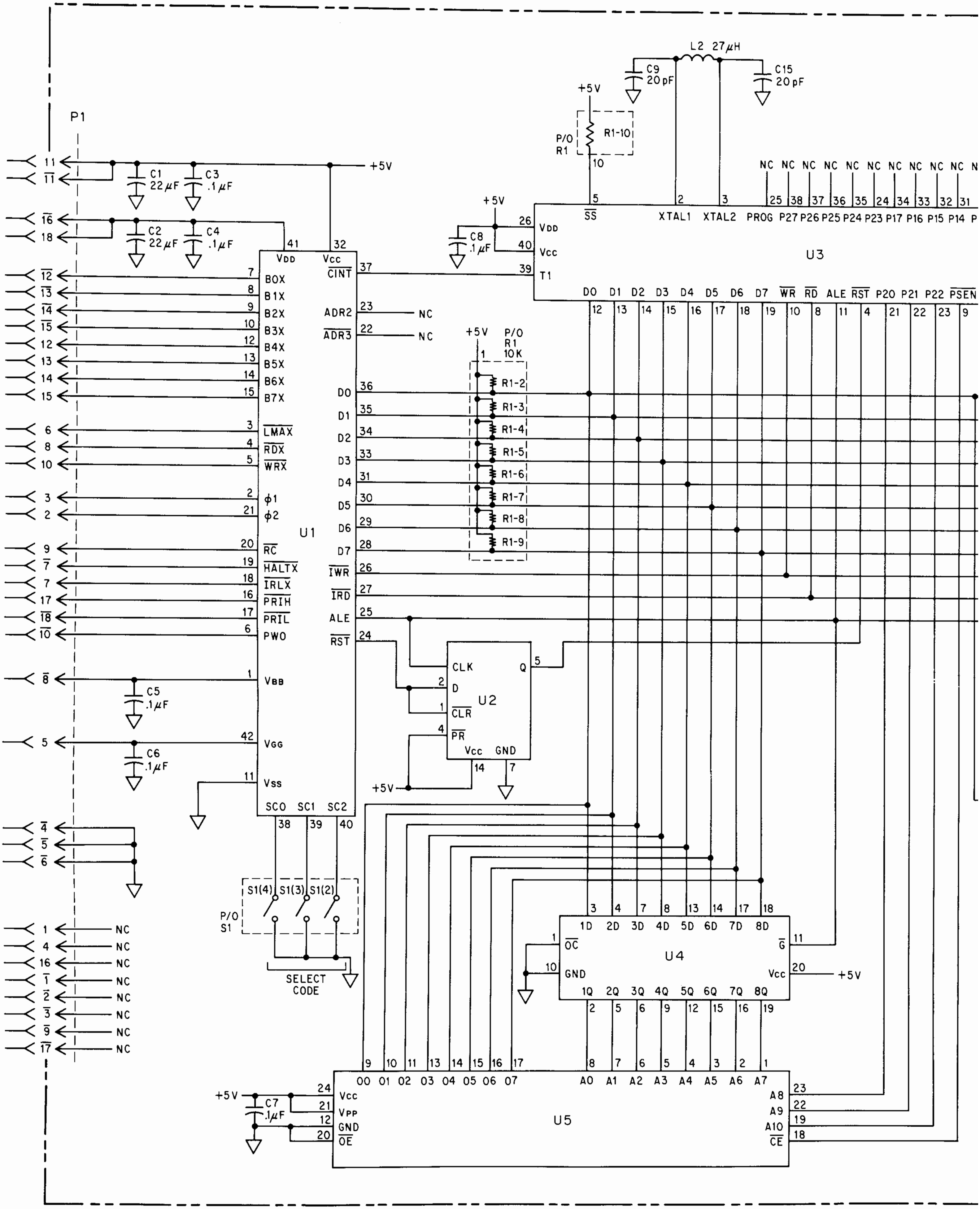
Table A-1. HP 82938A HP-IL Interface Replaceable Parts

HP Part Number	Description	Quantity
4040-2042	CASE, top	1
82938-60001	ASSEMBLY, printed circuit	1
0363-0174	CONTACT, ground	1
4040-2043	CASE, bottom	1
2200-0143	SCREW, machine, 4-40	7
2200-0521	SCREW, machine, 4-40	1
0624-0306	SCREW, tapping, 2-28	2
0950-0859	CONNECTOR, HPIL	1
8120-3383	ASSEMBLY, cable, 1m	1
1600-1182	BRACKET, connector	1

Table A-2. Interface PCA Replaceable Parts

Reference Designation	HP Part Number	Description	Quantity
C1, C2	0180-0228	CAPACITOR, 22 μF	2
C3-C8, C10, C11	0160-5332	CAPACITOR, 0.1 μF, 20%, 50V	8
C9, C15	0160-4767	CAPACITOR, 20 pF, 5%, 200V	2
C12	0160-4800	CAPACITOR, 120 pF, 5%, 100V	1
C13, C14	0160-4809	CAPACITOR, 390 pF, 5%	2
L1	9100-1631	INDUCTOR, 56 μH, 5%	1
L2	9100-1623	INDUCTOR, 27 μH, 5%	1
R1, R2	1810-0280	RESISTOR NETWORK, 10 kΩ	2
R3, R4	0698-3446	RESISTOR, 383Ω, 1%, .125W	2
R5, R6	0683-1535	RESISTOR, 15 kΩ, 5%, .25W	2
S1	3101-2533	SWITCH, four-segment	1
T1	9100-4236	TRANSFORMER, 5V	1
U1	1MB5-0101	IC, translator	1
U2	1820-1112	IC, dual D-type flip-flop (SN74LS74AN)	1
U3	1820-2271	IC, microcomputer (8039)	1
U4	1820-2102	IC, eight-bit latch (SN74LS373N)	1
U5	1818-0498	IC, 2k-byte EPROM (D2716)	1
U6	1820-1445	IC, four-bit latch (SN74LS375N)	1
U7	1LB3-0003	IC, HPIL	1
VR1—VR4	1902-0970	DIODE, Zener, 33V, .4W	4


SYSTEM CONTROLLER
EA
GND
INT
P11 P10
NC NC
28 27
S1(1)
P/O S1
+5V
P/O R2 10K
R2-2
R2-3
R2-4
R2-5
R2-6
R2-7
R2-8
R2-9
U7
IRQ
Vcc
D0
D1
D2
D3
D4
D5
D6
D7
WR
RD
RST
CS
RS2
RS1
RS0
GND
SCTL
LC2
LC1
A7
A6
TXD1
TXD0
RXD1
RXD0
TSCLK
NC
C11 .1µF
C12 120 pF ± 5%
L1 56µH ± 5%
R3 383 1%
R4 383 1%
C13 390 pF
C14 390 pF
VR1
VR2
VR3
VR4
R5 15K
R6 15K
P/O T1
P2
U6
G1,2
G3,4
D4
D3
D2
D1
Q4
Q3
Q2
Q1
GND
Vcc
C10 .1µF


P1
+5V
C1 22μF
C3 .1μF
C2 22μF
C4 .1μF
C5 .1μF
C6 .1μF
C7 .1μF
C8 .1μF
C9 20pF
C15 20pF
L2 27μH
P/O R1
R1-10
P/O R1 10K
R1-2
R1-3
R1-4
R1-5
R1-6
R1-7
R1-8
R1-9
U1
VDD
VCC
CINT
B0X
B1X
B2X
B3X
B4X
B5X
B6X
B7X
ADR2
ADR3
D0
D1
D2
D3
D4
D5
D6
D7
LMAX
RDX
WRX
φ1
φ2
RC
HALTX
IRLX
PRIH
PRIL
PWO
IWR
IRD
ALE
RST
VBB
VGG
VSS
SC0 SC1 SC2
NC
U2
CLK
D
CLR
PR
Q
Vcc GND
U3
SS
XTAL1 XTAL2 PROG P27 P26 P25 P24 P23 P17 P16 P15 P14
T1
WR RD ALE RST P20 P21 P22 PSEN
P/O S1
S1(4) S1(3) S1(2)
SELECT CODE
U4
1D 2D 3D 4D 5D 6D 7D 8D
OC
G
GND
Vcc
1Q 2Q 3Q 4Q 5Q 6Q 7Q 8Q
U5
O0 O1 O2 O3 O4 O5 O6 O7
A0 A1 A2 A3 A4 A5 A6 A7
A8
A9
A10
CE
VPP
OE

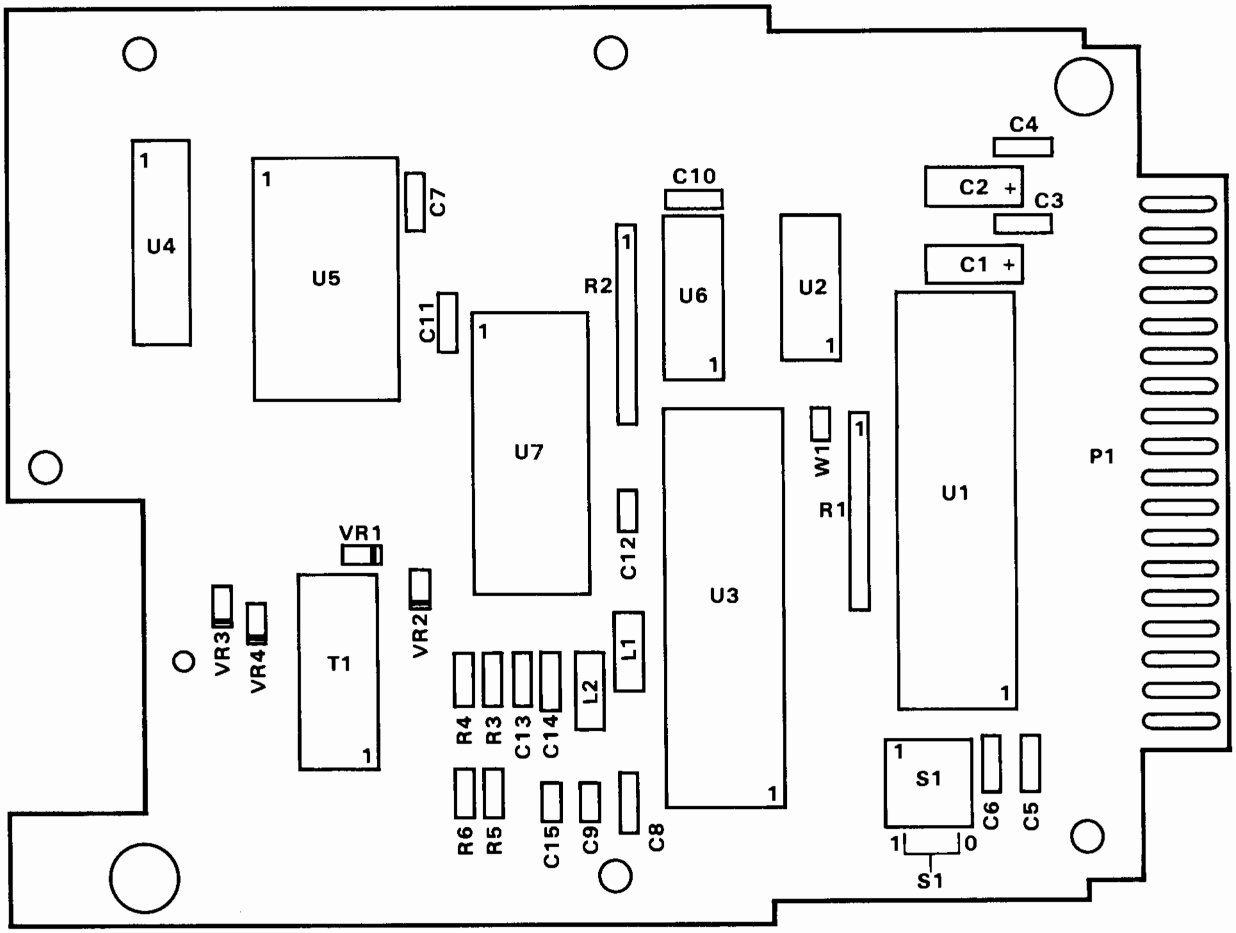


Figure A-2. Schematic Diagram

Appendix B

HP-IL Error Messages

Number	Meaning	Possible Cause
110	Self-test error	Probable hardware failure.
111	Invalid I/O	An attempt was made to access a nonexistent register or to execute a command not supported by the HP-IL interface.
113	Take control error	The take control message (TCT) sent was ignored by the device.
114	Not active controller	The statment executed requires the interface to be active controller.
115	Not active talker	The interface has not been addressed to talk. The loop must be properly configured for data transfer.
116	Not active listener	The interface has not been addressed to listen. The loop must be properly addressed for data transfer.
117	Currently active controller	The statement requires the interface to be non-controller.
118	Loop error	A transmission error or protocol violation occurred.
119	Start of transmission	The addressed talker ignored the start of transmission (SOT) message.

Appendix C

ASCII Character Set

HP Series 80 and ASCII Character Sets

EQUIVALENT FORMS				EQUIVALENT FORMS				EQUIVALENT FORMS				EQUIVALENT FORMS			
Series 80 Key	Binary	ASCII	Dec	Series 80 Key	Binary	ASCII	Dec	Series 80 Key	Binary	ASCII	Dec	Series 80 Key	Binary	ASCII	Dec
⋕ $@^c$	00000000	NULL	0	SPACE	00100000	space	32	@	01000000	@	64	` KEY LABEL^s	01100000	'	96
ȧ A^c	00000001	SOH	1	!	00100001	!	33	A	01000001	A	65	a	01100001	a	97
⊠ B^c	00000010	STX	2	"	00100010	"	34	B	01000010	B	66	b	01100010	b	98
Ñ C^c	00000011	ETX	3	#	00100011	#	35	C	01000011	C	67	c	01100011	c	99
α D^c	00000100	EOT	4	$	00100100	$	36	D	01000100	D	68	d	01100100	d	100
β E^c	00000101	ENQ	5	%	00100101	%	37	E	01000101	E	69	e	01100101	e	101
Γ F^c	00000110	ACK	6	&	00100110	&	38	F	01000110	F	70	f	01100110	f	102
ñ G^c	00000111	BEL	7	'	00100111	'	39	G	01000111	G	71	g	01100111	g	103
Δ H^c	00001000	BS	8	(	00101000	(	40	H	01001000	H	72	h	01101000	h	104
σ I^c	00001001	HT	9	)	00101001	)	41	I	01001001	I	73	i	01101001	i	105
↑ J^c	00001010	LF	10	*	00101010	•	42	J	01001010	J	74	j	01101010	j	106
λ K^c	00001011	VT	11	+	00101011	+	43	K	01001011	K	75	k	01101011	k	107
μ L^c	00001100	FF	12	,	00101100	,	44	L	01001100	L	76	l	01101100	l	108
M^c	00001101	CR	13	−	00101101	-	45	M	01001101	M	77	m	01101101	m	109
τ N^c	00001110	SO	14	.	00101110	.	46	N	01001110	N	78	n	01101110	n	110
‡ O^c	00001111	SI	15	/	00101111	/	47	O	01001111	O	79	o	01101111	o	111
Θ P^c	00010000	DLE	16	0	00110000	0	48	P	01010000	P	80	p	01110000	p	112
Ω Q^c	00010001	DC1	17	1	00110001	1	49	Q	01010001	Q	81	q	01110001	q	113
δ R^c	00010010	DC2	18	2	00110010	2	50	R	01010010	R	82	r	01110010	r	114
Å S^c	00010011	DC3	19	3	00110011	3	51	S	01010011	S	83	s	01110011	s	115
å T^c	00010100	DC4	20	4	00110100	4	52	T	01010100	T	84	t	01110100	t	116
Ä U^c	00010101	NAK	21	5	00110101	5	53	U	01010101	U	85	u	01110101	u	117
ä V^c	00010110	SYNC	22	6	00110110	6	54	V	01010110	V	86	v	01110110	v	118
Ö W^c	00010111	ETB	23	7	00110111	7	55	W	01010111	W	87	w	01110111	w	119
ö X^c	00011000	CAN	24	8	00111000	B	56	X	01011000	X	88	x	01111000	x	120
Ü Y^c	00011001	EM	25	9	00111001	9	57	Y	01011001	Y	89	y	01111001	y	121
ü Z^c	00011010	SUB	26	:	00111010	:	58	Z	01011010	Z	90	z	01111010	z	122
Æ $[^c$	00011011	ESC	27	;	00111011	;	59	[	01011011	[	91	π /^{s}	01111011	{	123
æ $\backslash^c$	00011100	FS	28	<	00111100	<	60	\	01011100	/	92	|	01111100	|	124
≠ $]^c$	00011101	GS	29	=	00111101	=	61	]	01011101	]	93	→ −^{s}	01111101	}	125
£ $\wedge^c$	00011110	RS	30	>	00111110	>	62	^	01011110	<	94	Σ *^{s}	01111110	~	126
▒ $\_^c$	00011111	US	31	?	00111111	?	63	_	01011111	—	95	⊢ +^{s}	01111111	DEL	127

Appendix D

Capability Subsets

Function	Description
R	Receiver. Complete capability.
AH	Acceptor handshake. Complete capability.
SH1	Source handshake. Complete capability.
D	Driver. Complete capability.
L1, 3	Listener. Basic listener, unaddress of MTA.
LE0	Extended listener. No capability.
T1, 2, 4, 6	Talker. Basic talker, send status, send accessory identification, unaddress if MLA.
TE0	Extended talker. No capability.
C1, 2, 3, 4, 5, 6, 7	Controller. Basic controller, system controller, respond to SRQ, pass and receive control, parallel poll, asynchronous IDY, assign auto address.
DC2	Device clear. Universal and addressed device clear commands made available to the user.
DT1	Device trigger. Trigger command made available to the user.
PP1	Parallel poll. Complete capability.
SR2	Service request. Basic and asynchronous request capability.
AA1	Auto address. Complete capability.
AE0	Auto extended address. No capability.
AM0	Auto multiple address. No capability.
RL2	Remote local. Basic capability with local lockout.
PD0	Power down. Basic capability.
DD1	Device dependent commands. Device dependent commands are made available to the user.

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