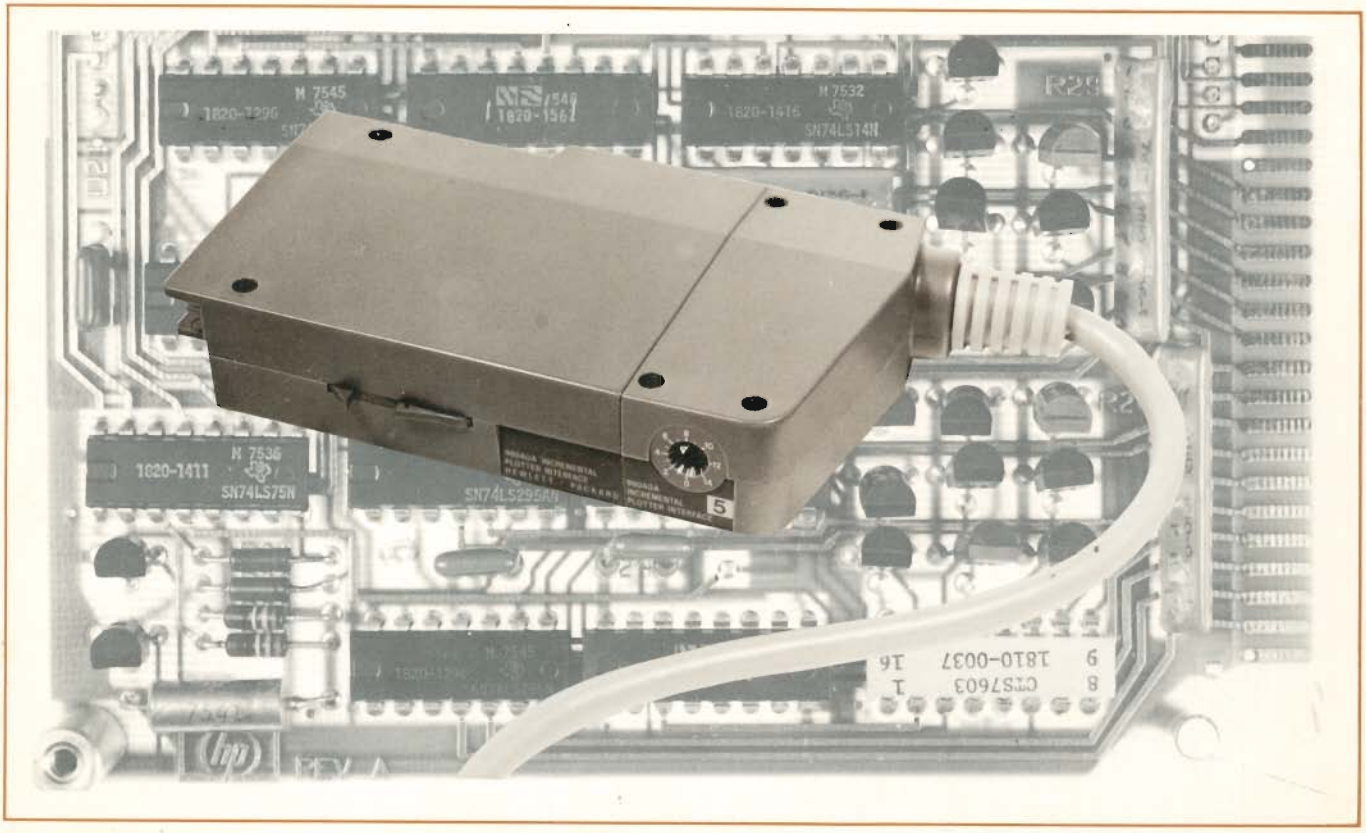
Hewlett-Packard 98040A
Incremental Plotter Interface
Installation and Service Manual



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98040A
Incremental Plotter Interface Installation and Service Manual

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P.O. Box 301, Loveland, Colorado 80537
(For World-wide Sales and Service Offices see back of manual.)

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Chapter 1
General Information

Introduction

The HP 98040A Incremental Plotter Interface is used to connect an HP Desktop Computer to various incremental plotters. This manual explains the procedure used to install the interface, the interface theory of operation and the diagnostic test and troubleshooting procedure. Complete interface schematics, component locators and replaceable parts lists are also provided.

Technical Specifications

Temperature Range:	0 to 45° C Ambient
Power:	+5 Volts 200ma, obtained from the computer
	+12 Volts 12ma, obtained from the computer
Dimensions:	Approximately 16.3 x 8.9 x 3.8 cm (6.4 x 3.5 x 1.5 in)
Cable length:	Standard – 2.0m (6.5 ft.)
Data Output Lines:	6 Pulsed Drive Lines
	+X, −X, +Y, −Y, Pen Up and Pen Down
	4 Latched Lines
	Pen 1, Pen 2, Pen 3 and Pen 4

Output Signal Characteristics

Output Level:	+12V or +5V (selected by a switch) on the drive and pen control lines. Output impedance of 500 ohms. Standard TTL level on the 4 latched lines.
Pulse Width:	20μsec or 50μsec on the drive and pen control lines (selected by a switch)
Pulse Rate:	100 pulses/sec to approximately 5000 pulses/sec (selected by switches). Rate change in steps of approximately 100 pulses/sec.
Pen Delay:	Pen up 15 or 30msec Pen down 30 or 60msec } (both selected by switches)

Chapter 2
Installation

Introduction

The installation procedure typically consists of the following steps:

- Setting the interface select code.
- Setting the output signal switches.
- Connecting the interface to the computer and plotter.

Select Code

The select code should be checked for the proper setting as required by your system. The select code is preset at the factory to select code 5. If it is necessary to change the setting, rotate the select code switch (shown below) to the desired setting using a small screwdriver.

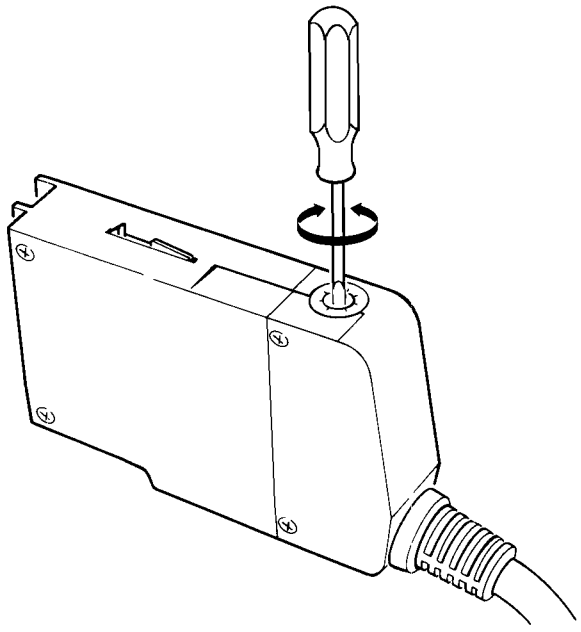


Figure 2-1:
Select Code Switch

You should not set more than one interface to the same select code or use any of the select codes that are reserved for the computer's internal peripherals (listed in Table 2-1).

Table 2-1:

Internal Computer Peripheral

Select Codes

Select Code	Internal Peripheral
0	Keyboard and printer
13	Graphics (if available)
14	Tape (optional)
15	Tape
16	CRT

Setting the Output Data Switches

Data Pulse

The data output to the plotter consists of a negative pulse of a specified duration (shown in Figure 2-2). The voltage level of the pulse, its duration and rate are characteristics that must be set to be compatible with the plotter being driven by the 98040 interface. Refer to the installation manual for the plotter's pulse specifications and switch settings for selected plotters.

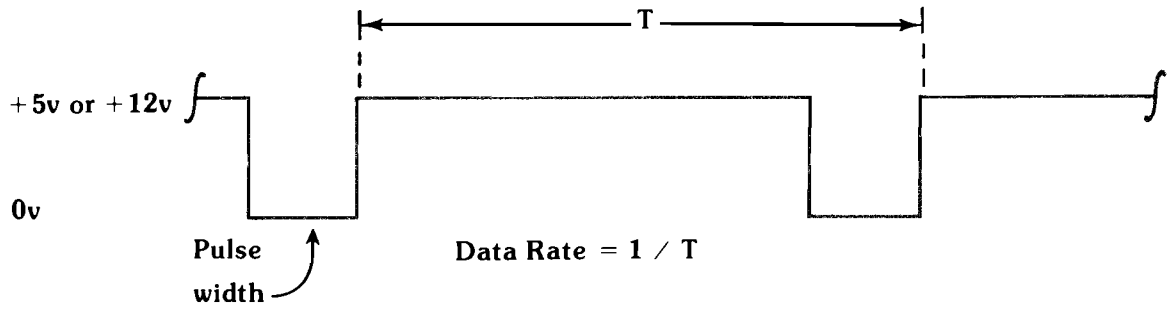


Figure 2-2:

Output Date Pulse

The Output Data Switches

The switches S1 and S2, which are used to select the various characteristics of the output data pulses, are located on the A2 board of the interface. The following procedure can be used to access these switches.

1. Remove the four screws from the rear housing as shown in Figure 2-3.

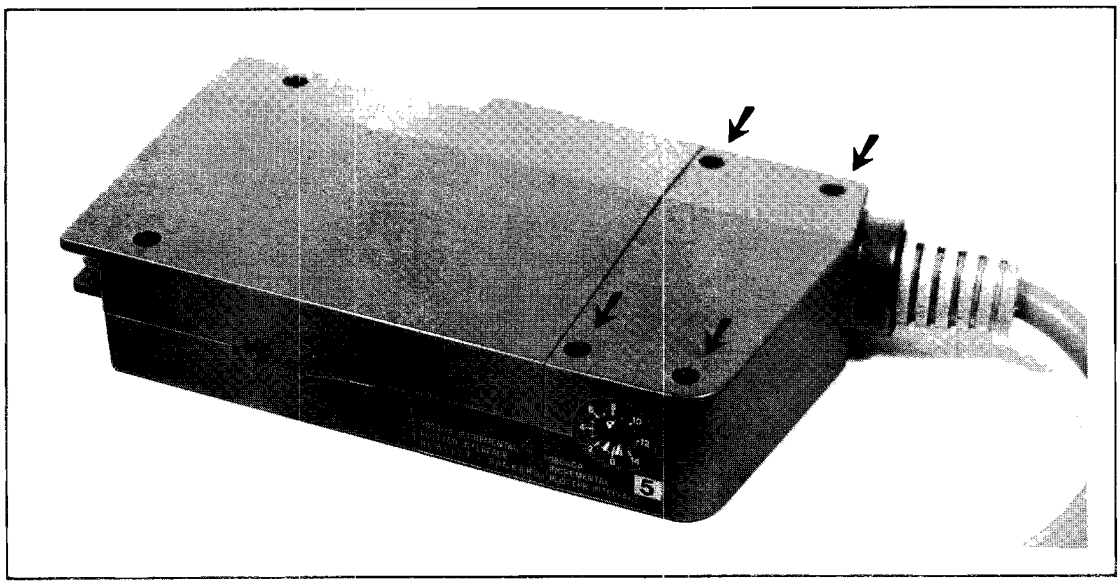


Figure 2-3:

Removing the Rear Housing Screws

2. Remove this half of the rear housing from the interface. Figure 2-4 shows the location of the switches.

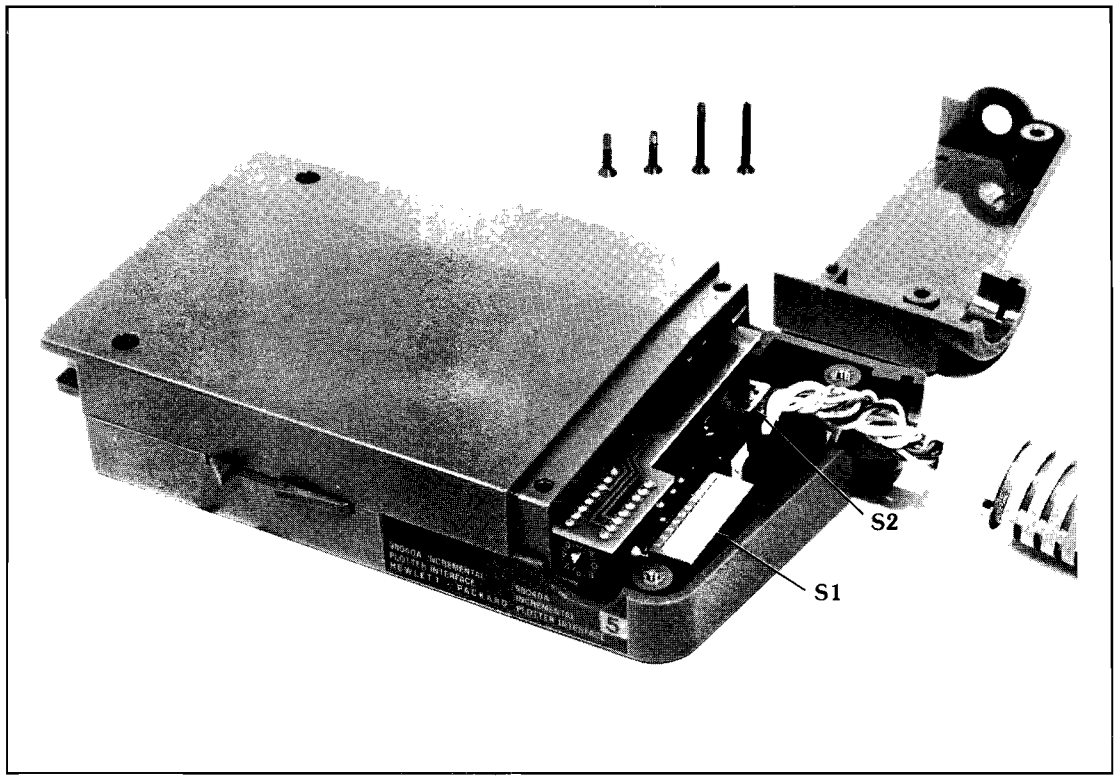


Figure 2-4:
Switch Locations

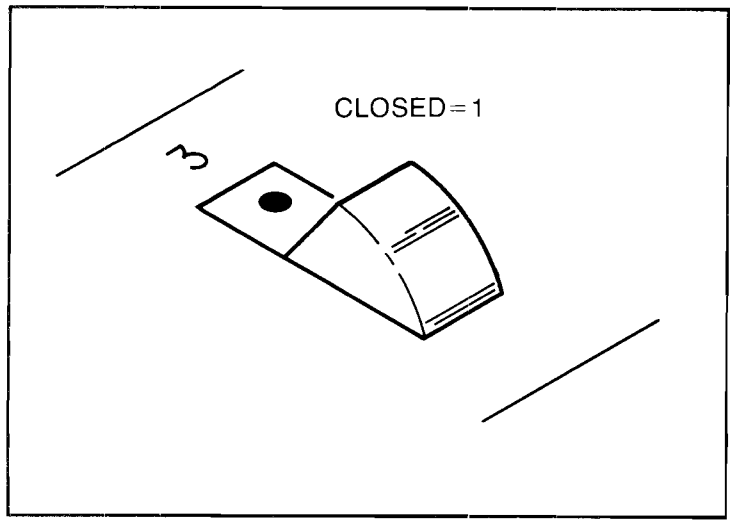
The Pulse Voltage Level

The voltage level of the output data pulse is set to a +5v level at the factory. If your plotter requires a pulse voltage level of +12v, set the voltage level switch S2 (shown in Figure 2-4) to the +12v position.

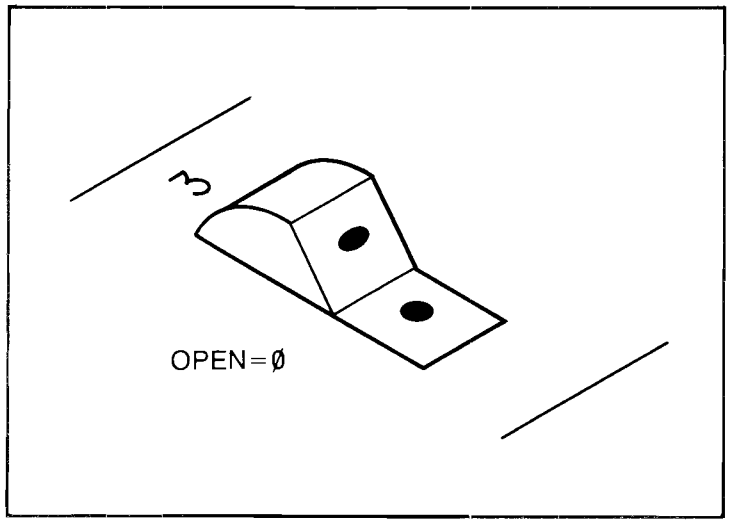
The Pulse Characteristic Switches

The 10 switches comprising S1 are used to select various characteristics of the output data pulse such as pulse width, pulse rate, pen-up and pen-down pulse delays and the data mode of the computer (bytes or words).

Pressing the top of the switch sets the closed or 1 position as shown below.

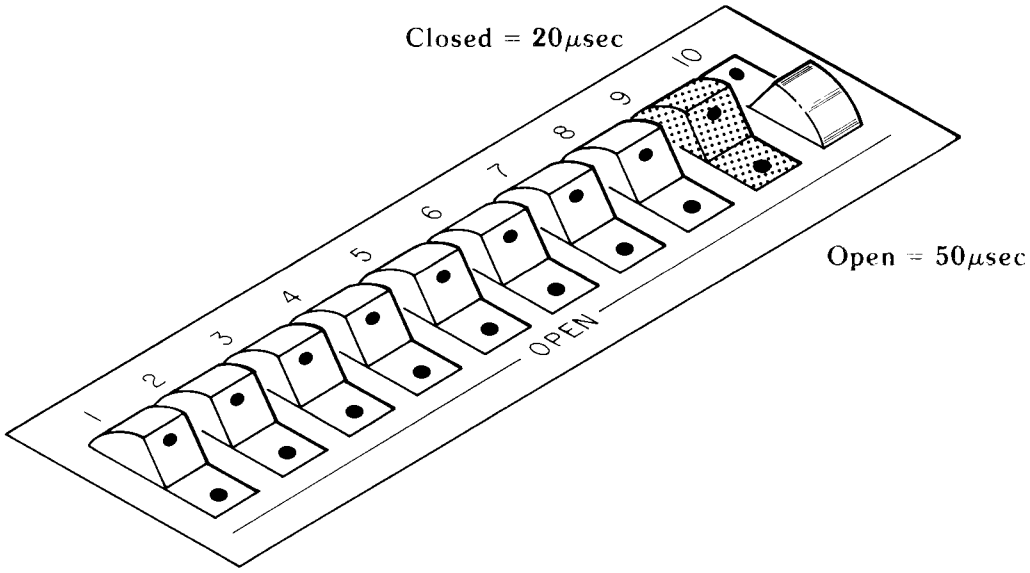


Pressing the bottom of the switch sets the open or 0 position as shown below.



Pulse Width Switch Settings

Switch 9 of S1 selects the output data pulse width as shown below:



Setting S1-9 to the closed position selects a pulse width of 20μsec and setting the switch to the open position selects a pulse width of 50μsec.

Pulse Rate Switch Setting

The switches 1 thru 6 of S1 are used to select the output data pulse rate that is compatible with the particular plotter being used. Table 2-2 lists the switch positions and the pulse rates that they select for both of the pulse widths availiable. The 1 values in the table correspond to the closed switch position and the 0 values correspond to the open switch position.

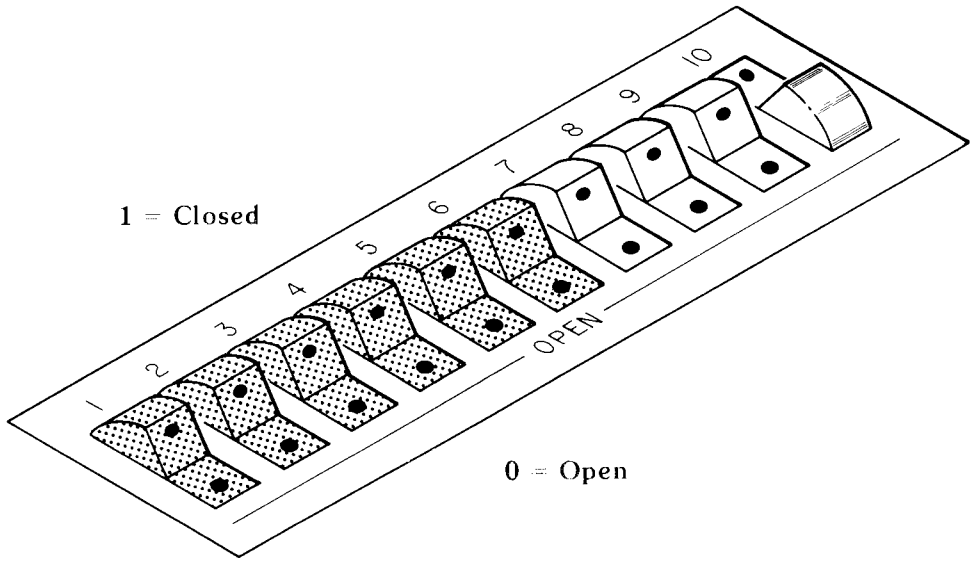


Table 2-2:

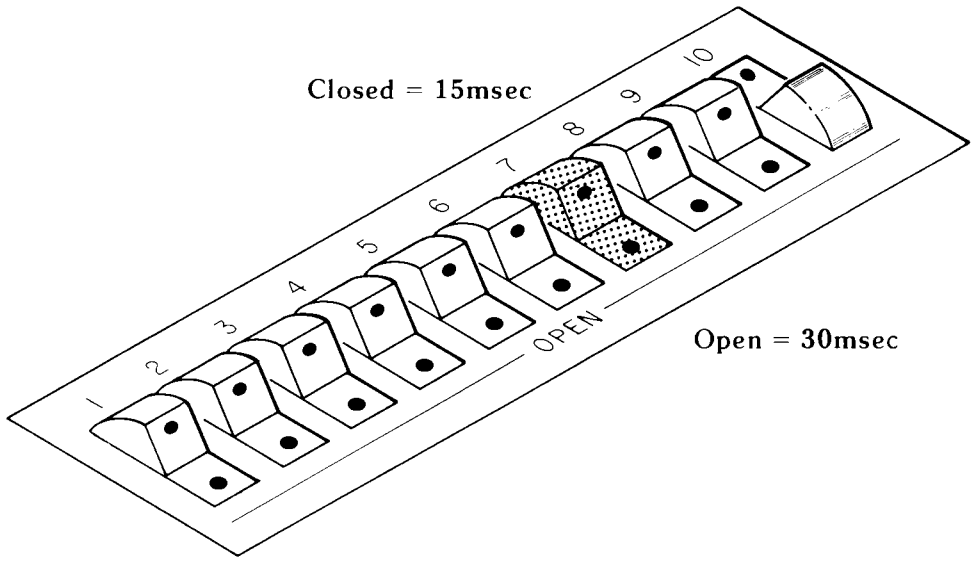
Pulse Rate Switch Settings

1 2 3 4 5 6	20 μsec	50 μsec
1 0 0 0 0 0	100	100
0 1 0 0 0 0	200	200
1 1 0 0 0 0	300	300
0 0 1 0 0 0	400	395
1 0 1 0 0 0	500	490
0 1 1 0 0 0	600	585
1 1 1 0 0 0	695	680
0 0 0 1 0 0	795	775
1 0 0 1 0 0	890	870
0 1 0 1 0 0	990	960
1 1 0 1 0 0	1085	1050
0 0 1 1 0 0	1185	1145
1 0 1 1 0 0	1280	1230
0 1 1 1 0 0	1375	1320
1 1 1 1 0 0	1470	1405
0 0 0 0 1 0	1605	1530
1 0 0 0 1 0	1700	1615
0 1 0 0 1 0	1795	1700
1 1 0 0 1 0	1885	1785
0 0 1 0 1 0	1980	1870
1 0 1 0 1 0	2075	1950
0 1 1 0 1 0	2165	2035
1 1 1 0 1 0	2255	2115
0 0 0 1 1 0	2350	2195
1 0 0 1 1 0	2440	2275
0 1 0 1 1 0	2530	2355
1 1 0 1 1 0	2620	2430
0 0 1 1 1 0	2715	2510
1 0 1 1 1 0	2805	2590
0 1 1 1 1 0	2895	2660

1 2 3 4 5 6	20 μsec	50 μsec
1 1 1 1 1 0	2980	2740
0 0 0 0 0 1	3185	2910
1 0 0 0 0 1	3270	2980
0 1 0 0 0 1	3360	3050
1 1 0 0 0 1	3450	3125
0 0 1 0 0 1	3535	3200
1 0 1 0 0 1	3625	3270
0 1 1 0 0 1	3710	3340
1 1 1 0 0 1	3795	3410
0 0 0 1 0 1	3885	3480
1 0 0 1 0 1	3970	3545
0 1 0 1 0 1	4055	3615
1 1 0 1 0 1	4140	3680
0 0 1 1 0 1	4225	3750
1 0 1 1 0 1	4310	3815
0 1 1 1 0 1	4390	3800
1 1 1 1 0 1	4475	3945
0 0 0 0 1 1	4595	4040
1 0 0 0 1 1	4675	4100
0 1 0 0 1 1	4760	4165
1 1 0 0 1 1	4840	4230
0 0 1 0 1 1	4925	4290
1 0 1 0 1 1	5010	4355
0 1 1 0 1 1	5090	4415
1 1 1 0 1 1	5170	4475
0 0 0 1 1 1	5250	4535
1 0 0 1 1 1	5330	4595
0 1 0 1 1 1	5410	4655
1 1 0 1 1 1	5490	4715
0 0 1 1 1 1	5570	4775
1 0 1 1 1 1	5650	4830
0 1 1 1 1 1	5730	4890
1 1 1 1 1 1	5810	4950

The Pen-up Delay

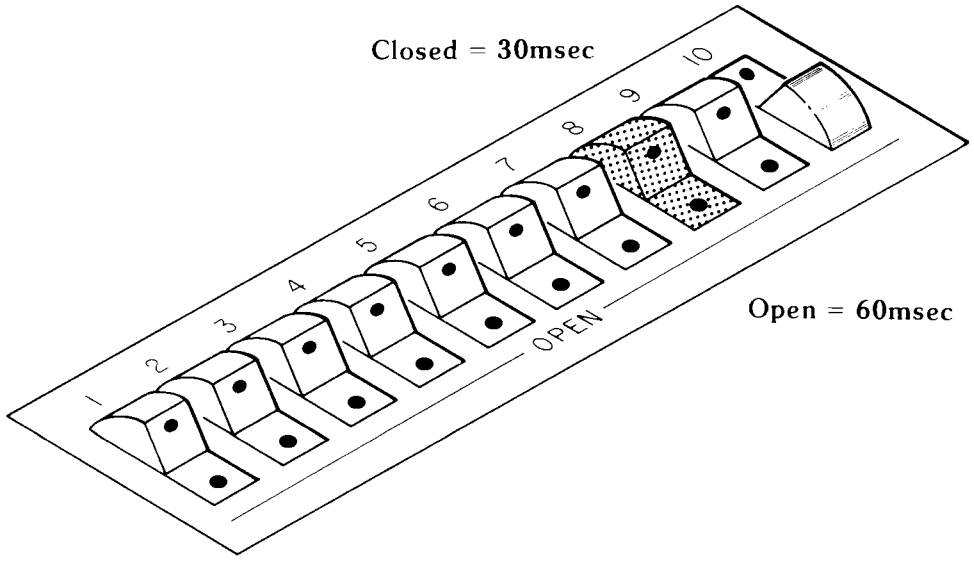
Switch S1-7 selects the length of time that the interface will wait after sending a pen-up data pulse before it will send additional data to the plotter.



Setting S1-7 to the closed position selects a 15msec delay and setting the switch to the open position selects a 30msec delay.

The Pen Down Delay

Switch S1-8 selects the length of time that the interface will wait after sending a pen-down data pulse before it will send additional data to the plotter.

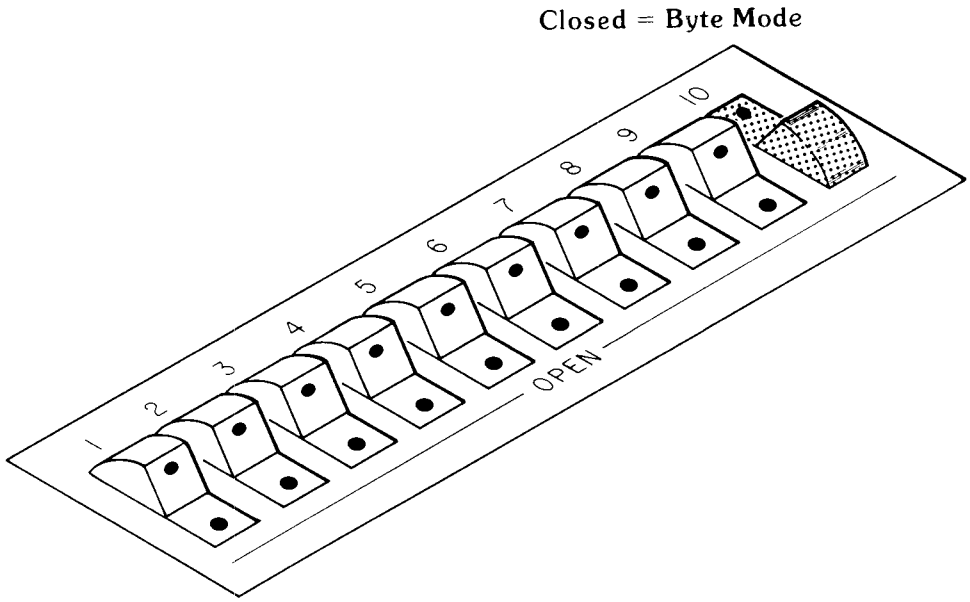


Setting S1-8 to the closed position selects a 30msec delay and setting the switch to the open position selects a 60msec delay.

The Computer Data Mode Switch

Switch S1-10 is set for the type of data that the computer outputs to the interface for transfer to the plotter. This data can be either 8-bit bytes or 16-bit words depending upon the computer that is being used to control the plotter.

S1-10 must be set to the closed position (shown below) for use with HP desktop computers.



After the interface switches have been set to select the data pulse characteristics that are compatible with the plotter in your system, reinstall the rear housing on the interface.

Connecting the Interface

The following procedure should be followed when connecting the 98040 interface to the computer and plotter.

1. Switch both the computer and plotter off.
2. Plug the interface housing into an empty I/O slot on the back panel of the computer. The select code switch should be facing up.
3. Connect the other end of the interface cable to the plotter in your system.
4. Switch the power on to both the computer and the plotter.

The PLOTTER IS Statement

The PLOTTER IS statement is used by the computer to select the plotting peripheral that will receive any plotting statements that are executed by the computer.

When the 98040 Incremental Plotter Interface is to be selected, the following syntax is used:

PLOTTER IS [select code,] "INCREMENTAL" [, step size[, # of pens , pen offset , incremental plotter I.D.]]

If none of the optional parameters are specified, the following default parameters are assumed by the computer.

Select code	5
Step size	.254 mm
# of pens	1
Pen offset	0 mm
Incremental plotter I.D.	1 (single pen plotter)

For single pen plotters, the last three parameters need not be entered. Only the interface select code or step size need be entered if they differ from the default values.

If, however, you are using a multi-pen plotter, the last three parameters in the statement must be specified. The following table lists the incremental plotter I.D. values that select specific multi-pen plotters.

Table 2-3:

Incremental Plotter I.D. Values

I.D. Value	Plotter
1	Default for all single pen plotters
2	Houston Complot DP-8S3
3	Zeta 3600
4	Not Used
5	Offset the pen in the X direction
6	Offset the pen in the Y direction

Plotter I.D. values 5 and 6 are for use with multi-pen plotters that are not included in the table. When either a 5 or 6 value is specified, the computer provides for pen offset in the direction shown for the I.D. value when the pen statement is executed.

Multi-pen plotters that are not listed in Table 2-3 will also need a subroutine subprogram to select the pens. An example of such a subroutine is provided in the Appendix.

System Verification Test

The following test can be used to verify that the interface is properly configured and connected.

1. Initialize the plotter to its default conditions. Set the pen to be used for the plot to the desired orign point for the test.
2. Refer to your computer's System Test Manual for the procedure used to load the 98040A Verification Test from the System Test Cartridge.

   If you have a System Test Cartridge that does not have the 98040A Verification Test recorded on it, refer to the Appendix of this manual for a listing of the Verification program. Carefully enter each line of the program into the computer and press [RUN] to start the test.
3. When "INCREMENT SIZE IN MILLIMETERS" is displayed, enter the increment size of your plotter and press [CONT].
4. Compare the finished plot with the sample shown in Figure 2-5. Some variation between your plot and the sample plot may exist due to the varied increment size and resolution among different plotters. The plot, however, should be reasonably similiar to the sample.

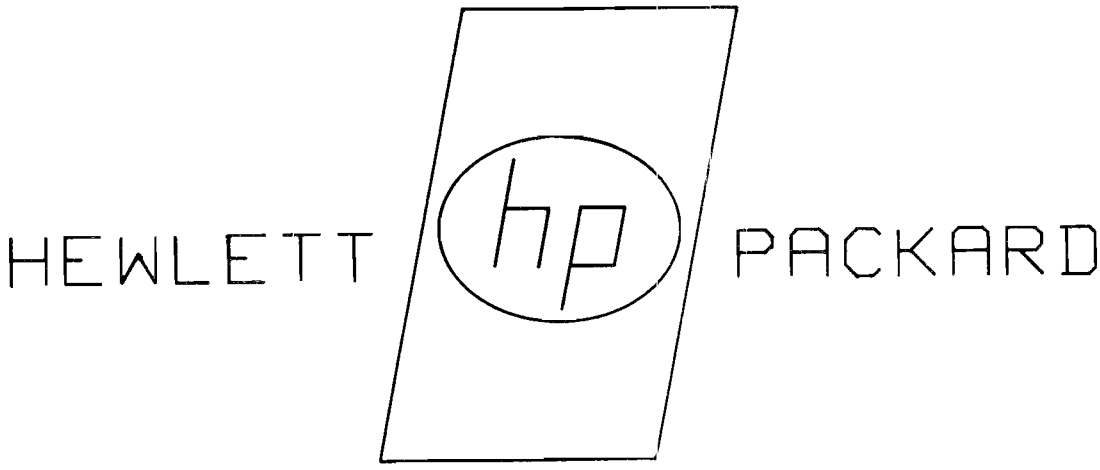


Figure 2-5:

Sample Plot

5. If the plot fails to run or the finished plot varies significantly from the sample, perform the following checks:

   a. Check all switch settings on the interface.

   b. Verify that the computer is functional. Refer to the computer's System Test Booklet.

   c. Verify that the plotter is functional. Refer to the plotter's Installation or Service Manual.

   d. If the plot still fails to run or if the plot varies significantly from the sample after verifying that both the computer and plotter are functioning properly, refer to Chapter 3 "Service" of this manual.

Chapter 3
Service

Introduction

This chapter contains a general theory of operation of the interface, a block diagram and general test and troubleshooting information. This chapter also contains complete circuit diagrams and component locators for both of the interface circuit boards as well as a list of replaceable parts.

If you have difficulty testing or repairing the interface or if you would rather have HP repair it, contact the nearest HP Sales and Service Office for assistance. A list of office locations is at the back of this manual.

Theory of Operation

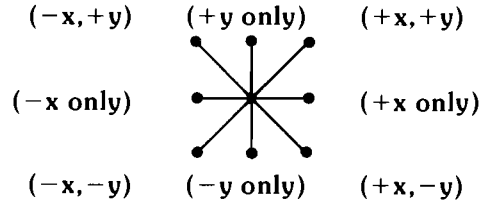
This section describes the operation of the 98040A Interface. Unfold the block diagram on page 33 for reference as you read this section.

NOTE

The logic sense used by this interface is negative-true. For simplicity in this manual, all line levels will be referred to as either a "high" signal (high = logical 0 = false) or a "low" signal (low = logical 1 = true).

General Overview

The 98040A interface receives specially formatted data from the computer and converts it into pulsed outputs on the four plotter drive lines (+x, −x, +y and −y), the pen-up and pen-down lines or the latched pen select lines. The drive lines specify the direction of the plotter's incremental pen movement according to the lines that are pulsed (shown below).



The actual distance that the plotter moves the pen for each increment is a characteristic of the specific plotter being used.

The pen-up and pen-down lines are pulsed to instruct the plotter to either raise the pen currently being used (pen-up) or to lower it (pen-down).

Functional Operation Description

The interface functions are categorized into four states:

- Command Accept State
- Pen Select State
- Data Output State
- Repeat Data State

These states are programmed by computer ROM firmware routines during the execution of either graphics or plotter statements.

The Command Accept State

The command accept state is set when both the S0 and S1 lines of the Control Logic are low. This state is set any time the PRESET signal is sent from the computer or when four lows are detected on the output lines of the multiplexer.

This state disables the Data Output Buffer and then reads the next 8-bits sent from the computer as either a command selecting another state or sending a pen-up/pen-down pulse to the plotter. If a plotter uses the 4 latched outputs for pen selection, the specific pen that is to be raised or lowered is selected from this state. These 4 lines are latched by the pen-down pulse.

In the Command Accept state the 8-bits of the byte are defined as follows:

IOD 7 = low

Remain in command accept state.

IOD 6 = low

IOD 5 – Pen-up when IOD 5 is high and IOD 4 is low.

IOD 4 – Pen-down when IOD 5 is low and IOD 4 is high.

IOD 3 thru IOD 0 – Selects the pen to be raised or lowered (for plotters that use the 4 latched output lines). A high level on a line causes the corresponding latched output to assume a low level.

The Pen Select State

If the 8-bits read from the command state have the bit levels shown below, the Pen Select state is selected.

IOD 7 = low – Sets S1 to low
IOD 6 = high – Sets S0 to high
IOD 5 thru IOD 0 = all low

In this state, the following 8-bit bytes are used to send 6-bit data on the 4 drive lines (+x, −x, +y and −y), the pen-up line and the pen-down line. This sequence selects the pen to be used on certain plotters with multiple pens. The bits of the 8-bit bytes that select pens from this state are defined as follows:

IOD 7 = low
IOD 6 = high

} Remains in the pen select state.

IOD 5 thru IOD 0 – Specify the pulses that will select a specific pen. A high level on an IOD line will pulse the corresponding output line. any combination of pulses is valid except those that have IOD 3 thru IOD 0 all low levels.

The Data Output State

If the interface is in the command accept state and the next 8-bit byte contains the bit values shown below, the data output state is selected.

IOD 7 = high – Sets S1 to high
IOD 6 = low – Sets S0 to low
IOD 5 thru IOD 0 = all low

In this state, the interface enables the Multiplexer Address lines to the Multiplexer and the Data Enable line to the Output Buffer. When the interface is in the Byte mode (S1-10 closed), data is transfered by the Multiplexer to the Output Buffer in two 4-bit portions; IOD 3 thru IOD 0 first followed by IOD 7 thru IOD 4. If the word mode (S1-10 open) is selected, the 16 bits of data are transfered as four 4-bit portions; IOD 3 thru IOD 0 first, then IOD 7 thru IOD 4, IOD 11 thru IOD 8 and IOD 15 thru IOD 12 last.

The interface remains in the Data Output state until either 4-bits of data consisting of all lows are detected by the No-Op Detector or the computer is reset (which pulses the $\overline{\text{PRESET}}$ line). When either of these conditions occur, the interface reverts to the Command Accept state.

The Repeat Data State

When the interface is in the Command Accept state, the following byte selects the Repeat Data state.

IOD 7 = high – Sets S1 high
IOD 6 = high – Sets S0 high
IOD 5 thru IOD 0 = all low

This state is used when the same output pulses are to be repeated a specific number of times. The S1 and S0 signals (both high) enable the Output Buffer and the counter inputs on the Register/Counters. The Multiplexer Address lines are disabled which causes only the data on IOD 3 thru IOD 0 to be transfered to the Output Buffer. The data bits on IOD 7 thru IOD 4 (IOD 16 thru IOD 4 in the Word Mode) specify the number of times that the data pulses (defined by IOD 3 thru IOD 0) are to be repeated. The maximum number of repetitions that can be specified is 16 in the Byte Mode and 4096 in the Word Mode.

The interface remains in the Repeat Data state until either 4-bits of data consisting of all lows are detected by the No-Op Detector or the computer is reset (which pulses the $\overline{\text{PRESET}}$ line). When any of these conditions occur, the interface reverts to the Command Accept state.

Block Diagram Summary

In this summary, the operation of each functional block of the diagram on page 33 is described.

The Peripheral Address Decoder

The Peripheral Address Decoder circuit (A1U4A through A1U4D) compares the peripheral address on the I/O bus to the select-code switch (A1S1) setting. If these two addresses are equal, the peripheral address decoder output (MYPA) is enabled (high). The peripheral address lines are, like all I/O bus lines, negative true. When MYPA is high, the interface can take control of the $\overline{\text{FLG}}$ and $\overline{\text{STS}}$ lines on the I/O bus.

Register Decoder

MYPA is AND'd (A1U2A) with the $\overline{INT}$ (no interrupt poll in progress) signal, this composite signal enables the Register Decoder (A1U13). The eight open-collector outputs of this decoder are the I/O register control signals. The I/O bus signals, $\overline{IC1}$ and $\overline{IC2}$, determine which register is being addressed. The following table relates the decoder output line mnemonics to its input lines.

Table 3-1. Register Decoder

Calculator I/O Bus Lines		Decoder Output Lines		
$\overline{IC2}$	$\overline{IC1}$	$\overline{DOUT}$	$\overline{IOSB}$	Mnemonic
high	high	high	X	R4IN
high	low	high	X	R5IN
low	high	high	X	R6IN
low	low	high	X	R7IN
high	high	low	low	R4SB
high	low	low	low	R5SB
low	high	low	low	R6SB
low	low	low	low	R7SB

high = false, low = true, X = don't care

The Register Decoder output lines are normally high. Four of these signals (R4IN through R7IN) are used to control the input operations and the other four signals (R4SB through R7SB) are used to strobe (clock) the output data. During an interrupt poll the register decoder is disabled by $\overline{INT}$.

Interrupt Logic

The Interrupt logic is enabled and disabled by bit 7 of register 5. When interrupt is enabled (bit 7 is low) the select-code switch setting determines which level of priority and which poll response bit the interface will use. The high-level interrupt (high priority) is used by devices with select codes 8 through 15. The low-level interrupt (low priority) is used by interfaces with select codes 0 through 7. It is recommended that the 98040A interface be set to a select code between 0 and 7 (5 is set at the factory) so that the incremental plotter operates on the low-level interrupt.

Poll Response

The lower three bits from the select-code switch are used as the inputs to a three-to-eight line decoder (A1U1). The open-collector outputs of the decoder are connected to the IOD 0 through IOD 7 lines. If the interrupt mode is set and the previous handshake is complete (I/O Bus FLAG – low, PFLG – Ready) the interface will request an interrupt. If the interrupt is set and a handshake is in progress (I/O Bus FLAG – high, PFLG – Busy) the interface will cause an interrupt when it completes the handshake (PFLG – Ready). This causes the interface to ground either $\overline{\text{IRL}}$ or $\overline{\text{IRH}}$ as determined by P3 of the select-code switch. These interrupt request lines are Wire-Or'd on the I/O bus. This allows more than one interface to simultaneously request interrupt service on the same interrupt level. When an interrupt request is received by the computer and the interrupt system is active, the computer does an interrupt poll. To initiate a poll the computer grounds the $\overline{\text{INT}}$ line, then each device requesting service will respond in the following manner. During a low-level poll, interfaces on select-codes 0 through 7 that are requesting service will ground the bit corresponding to its select code value. Interfaces on select codes 8 through 15 that are requesting service will respond to a high-level poll by grounding the IOD line corresponding to their select-code value minus eight. For example, an interface set to select-code 9 will ground IOD 1 (9-8 = 1) during a high-level poll if it is requesting service. Only those interfaces ennabled for interrupt and actively requesting service on $\overline{\text{IRL}}$ or $\overline{\text{IRH}}$ will respond to a poll.

Before an interface actively requests service, it first checks to see if an interrupt poll is already in progress. If a poll is in progress it will wait until $\overline{\text{INT}}$ returns to high. This is accomplished with the interrupt-active flip-flop (A1U5A) and A1U2B. The interrupt request logic sets the interrupt-active flip-flop when interrupt enable (bit 7 of register 5) is set, Direct Memory Access (DMA) is disabled and FLAG is high.

Direct Memory Access Logic

Direct Memory Access (DMA) is a high speed means of transfering data to and from the computer. Since plotters are relatively slow devices, DMA data transfers are generally not an efficient use of the computers capabilities. For this reason, the DMA logic is not used by the 98040A interface.

Handshake Logic

The Handshake Logic is used to synchronize the data exchange between the interface and the computer. The handshake is initiated by the computer and terminated by the interface. The interface may take as much time it requires to respond.

PCTL Line

$\overline{\text{PCTL}}$ is the handshake signal from the I/O Control Board to the Data Control Board. Its active state is control-set. When the interface is RESET (e.g., during power-up) the $\overline{\text{PCTL}}$ line state is

set to control-clear. The logic sense of the $\overline{\text{PCTL}}$ signal is low = control-set and high = control-clear.

PFLG Line

PFLG is the handshake line from the Data Control Board to the I/O Control Board. The two states of the PFLG line are busy and ready. The logic sense of the PFLG Line is low = busy and high = ready. PFLG is controlled by the flip-flops A2U9B and B. The $\overline{\text{PCTL}}$ line resets the flip-flop A2U9B which drives the PFLG line low (via U13) when a data transfer from the computer is initiated. When the interface has completed the transfer, one of the following lines drives the PFLG line high indicating that the interface is ready for another transfer:

- A high signal from A2U15 pin 12 if the interface is in either the Command Accept state or the Pen Select state.
- The $\overline{\text{NULL}}$ line via A2U15 pin 12 if the interface is in either the. Repeat Data state or the Data Output state.
- The $\overline{\text{CTZ}}$ line from the register/counter A2U5 if the interface is in the Repeat Data state.
- The $\overline{\text{LMOV}}$ line from A2U10D of the control logic multiplexer address circuit when the interface is in the Data Output state.

STS Line

The $\overline{\text{STS}}$ line is examined by the computer during an I/O operation. When $\overline{\text{STS}}$ is low, it indicates that the addressed interface is OK. If $\overline{\text{STS}}$ is high, there is either no interface addressed or the interface is NOT OK.

Data Registers/Counters

The data registers on the A2 board consist of one 4-bit register (A2U2) and three 4-bit register/counters (A2U6, A2U1 and A2U5).

Each data transfer to the interface always loads all of the register (16 bits). Only the Data Output state, however, can transfer all 16 bits (if the data mode switch (S1-10) is set to the word mode). The Command Accept state and the Pen Select state use only the lower 8 bits of data (IOD 7 thru IOD0) regardless of the mode (word or byte) set by S1-10.

The Repeat Data state enables A2U6, U1 and U5 as counters (via the S0 and $\overline{\text{STRB}}$ lines) that specify the number of times that the data in register A2U2 (IOD3 thru IOD0) is to be pulsed. In the word mode all three counters contain valid repetition data. In the byte mode, however, the data lines IOD15 thru IOD8 are always high and thus only data lines IOD7 thru IOD4 specify the number of repetitions.

16 to 4 Multiplexer

A2U3 and A2U7 form a 16 line to 4 line multiplexer that separates the 8-bit or 16-bit data from the computer into 4-bit portions for the plotter.

Control and Timing Logic

The control and timing logic provides the handshake, multiplexer addressing, state selection, data pulse generation and timing for the interface.

Handshake and Pulse Control

A2U9A and B receive the handshake line, $\overline{\text{PCTL}}$, and control the handshake line PFLG. A2U9B also generates the $\overline{\text{RUN}}$ signal that starts the pulse generator A2U12B and A2U17B. Switch S1-9 controls the width of the pulses and switches S1-1 thru S1-6 control the pulse rate.

Pen Control Delay

A2U12A generates the pen-up delay and A2U17A generates the pen-down delay.

Multiplexer Address Control

The Multiplexer is addressed by A2U4A and B to transfer data in either two 4-bit portions (in the Byte mode) or four 4-bit portions (in the Word mode) when the interface is in the Data Output state. When the interface is in either the Pen Select state or the Repeat Data state, the multiplexer is addressed to transfer only IOD 0 thru IOD 3.

No-OP Detector

The No-Op Detector (A2U11B) controls the line $\overline{\text{NULL}}$. This signal is high (true) whenever the four bits of data that are sent to the output buffer (A2U16) are all low.

Interface State Control

The state of the interface is selected by the outputs of JK flip-flops A2U8A and A2U8B. The outputs S0, $\overline{\text{S0}}$, S1 and $\overline{\text{S1}}$ enable or disable the various circuits on the interface as required by the state selected.

• Command Accept State	S0 = low	$\overline{\text{S0}}$ = high
	S1 = low	$\overline{\text{S1}}$ = high
• Pen Select State	S0 = high	$\overline{\text{S0}}$ = low
	S1 = low	$\overline{\text{S1}}$ = high
• Data Output State	S0 = low	$\overline{\text{S0}}$ = high
	S1 = high	$\overline{\text{S1}}$ = low
• Data Repeat State	S0 = high	$\overline{\text{S0}}$ = low
	S1 = high	$\overline{\text{S1}}$ = low

The states are programmed from the Command Accept state by the data on the IOD 7 (S1) and IOD 6 (S0) lines.

The Command Accept state is set whenever any of the following conditions occurrs:

- The computer is Reset which sends a low pulse on the preset line which resets the A2U9A and the A2U8A and B flip-flops, thus setting PFLG High and S1 and S0 low.
- The data bits on IOD 7 (S1) and IOD 6 (S0) are low and the interface is in the Command Accept state.

Data Output Buffer and Drivers

The Data Output Buffer (A2U16) is enabled by either S1 or S0 whenever data pulses are to be output to the plotter. The output drivers A2Q1, Q2, Q5 and Q7 ground the +5v or +12v output levels according to the data transfered by the multiplexer. This produces the drive pulse to the plotter.

Pen Outputs

The pen-up and pen-down pulses are enabled by the data on IOD 4 and IOD 5 during the Command Accept state. This data turns on one of the pen drivers, A2Q3 or Q4, which pulses the appropriate pen control output line.

The Latched Pen Select Outputs are used by some multi-pen plotters instead of the Pen Select state to select the pen to be used for plotting operations. These latched outputs are enabled during the Command Accept state by the pen-down line and receive their data from the IOD 0 thru IOD 3 lines.

State Diagram Flow Chart

The state diagram flow chart on the back of the Block Diagram foldout (page 34) shows the sequence of events and logic states that should exist for each of four operatioal states of the interface.

Troubleshooting

This section contains a description of the interface diagnostic test and a state diagram flow chart to aid in locating and repairing an interface failure.

Equipment Required

The following equipment is required to test the interface:

- Test Cartridge (Rev B or later for the 9845A)
- Test Connector (P/N 98041-67940).
- Oscilloscope

Interface Diagnostic Test

The following procedure should be followed to set up the interface for the diagnostic test.

1. Switch both the plotter and the computer off.
2. Disconnect the interface from both the plotter and the computer.
3. Open the rear housing of the interface as shown in Figure 3-1 A and B.

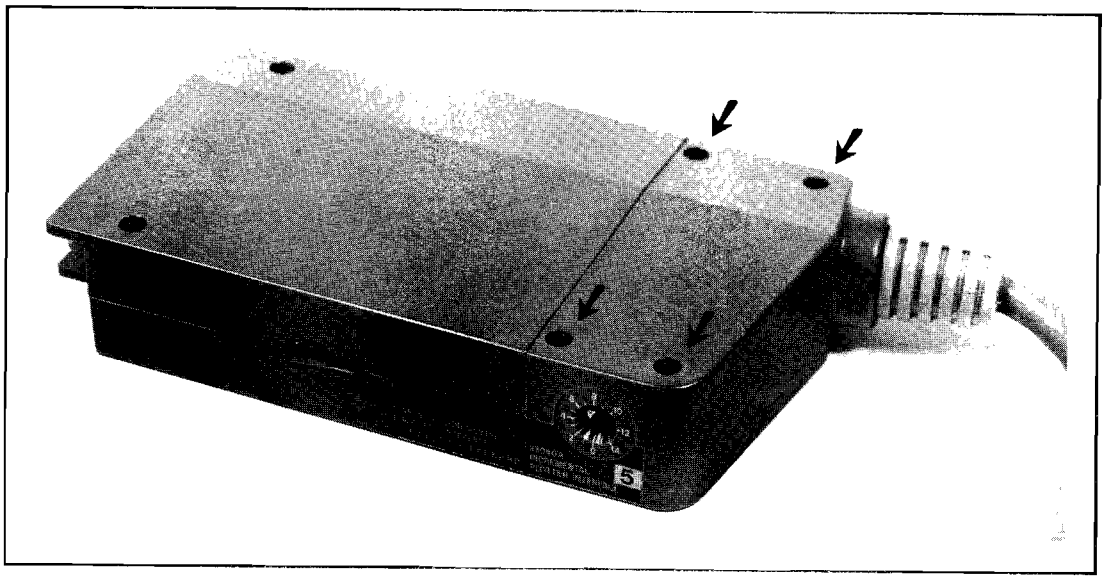


Figure 3-1 A:

Remove These Four Screws

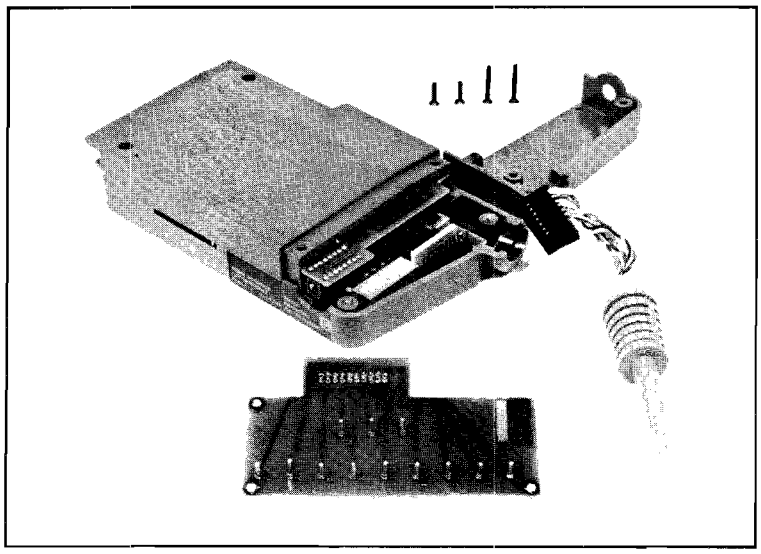


Figure 3-1 B:

Lift the Top Half of the Rear Housing and Unplug the Cable Assembly

4. Install the test connector in place of the cable assembly as shown in figure 3-2 below.

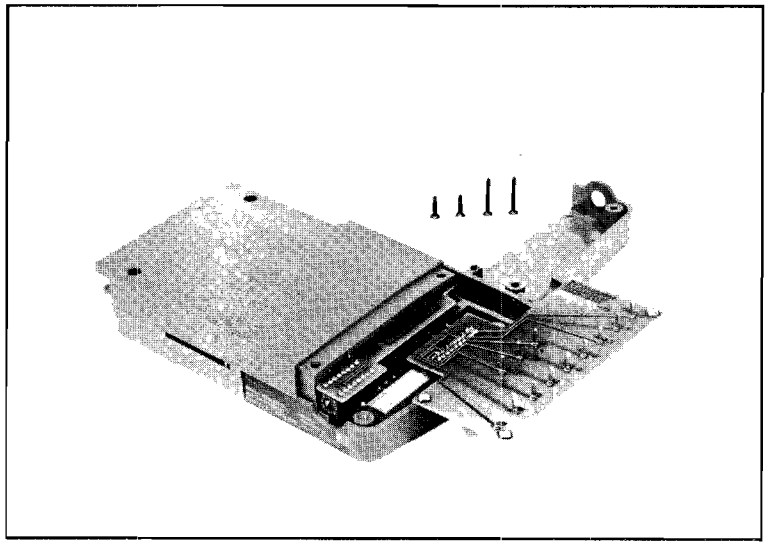


Figure 3-2:

Installing the Test Connector

Although the test connector provides convenient access to each of the output lines, the data signals can be taken directly from the output connector (P2) on the A2 circuit board if the test connector is not available. Refer to the A2 Data Control Board Component locator for the pin numbering sequence of the output connector, P2. Refer to the A2 Data Control Board Schematic for the output signals and their corresponding pin numbers on the P2 connector.

5. Reconnect the interface to the computer I/O slot. Switch the computer on.
6. Refer to your computer's System Test Manual for the procedure used to load the 98040A Diagnostic Test from the System Test Cartridge.

   If you have a System Test Cartridge that does not have the 98040A Diagnostic Test recorded on it, refer to the Appendix of this manual for a listing of the diagnostic program. Carefully enter each line of the program into the computer and press [RUN] to start the test.
7. Connect the oscilloscope to the first output to be tested. The diagnostic test begins by pulsing the pen #1 line.

To check any other output line, connect the oscilloscope to the desired output test point and press the special function key (listed below) that corresponds to the line to be tested. The program will then begin to pulse that line. The strobe output line is pulsed with all output lines.

Key	Line Pulsed
[k0]	Pen 1
[k1]	Pen 2
[k2]	Pen 3
[k3]	Pen 4
[k4]	Pen Up
[k5]	Pen Down
[SHIFT] [k0]	+X
[SHIFT] [k1]	−X
[SHIFT] [k2]	+Y
[SHIFT] [k2]	−Y

Shown next are samples of the typical oscilloscope wave forms that should be seen during the testing of the various output lines. Listed with each wave form are the oscilloscope and the interface settings that generated the output wave form.

The Data Drive Pulses

OSCILLOSCOPE SETTINGS

50μsec/div
5V/div

INTERFACE SWITCH SETTINGS

Highest data rate (S1−1 thru S1−6 closed)
50μsec pulse width (S1−9 open)
12V setting (S2 at 12V setting)

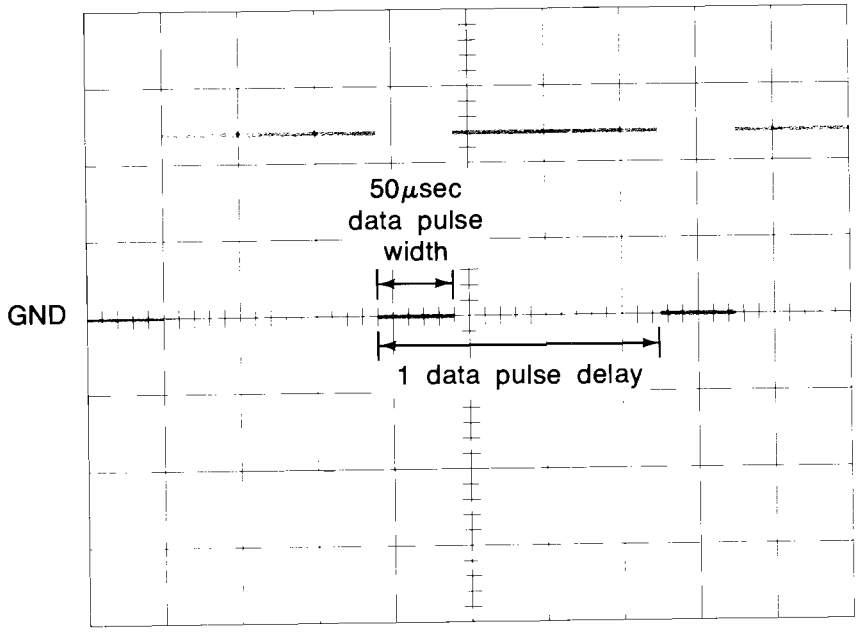


Figure 3-3:

Data Pulse Display

(+X, +Y)

The data lines are pulsed in the Repeat Data state. At higher data rates a delay of up to 10msec (caused by the computer's program execution rate and transfer delays in the interface) will appear between repeat cycles. Therefore, you should only check the data rate during the pulse repetition cycle (16 pulses per repetition) as shown in Figure 3-4.

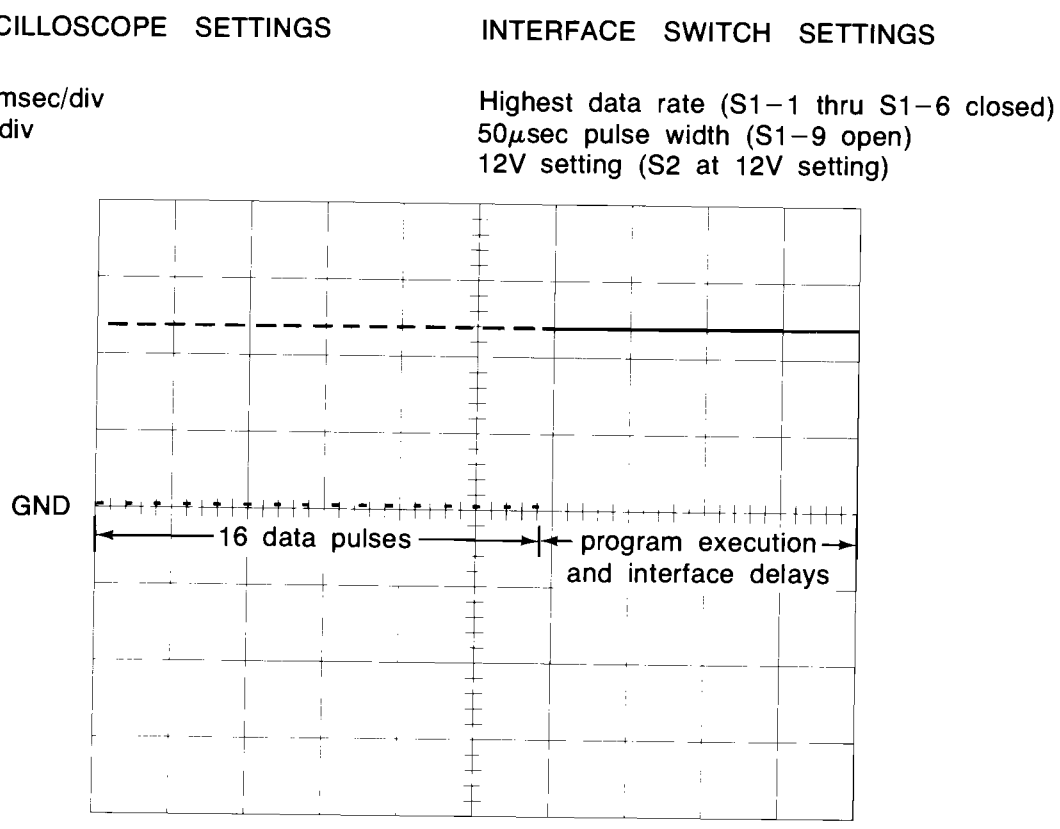


Figure 3-4:

Illustration of Repeat Mode and Delay Before Next Cycle

The Pen Up and Pen Down Pulses

The pen up and pen down pulses (shown in Figure 3-5) are similar in wave form to the data drive pulses except for the addition of the pen up or pen down delay times.

OSCILLOSCOPE SETTINGS

5msec/div
5V/div

INTERFACE SWITCH SETTINGS

Highest data rate (S1−1 thru S1−6 closed)
50μsec pulse width (S1−9 open)
12V setting (S2 at 12V setting)

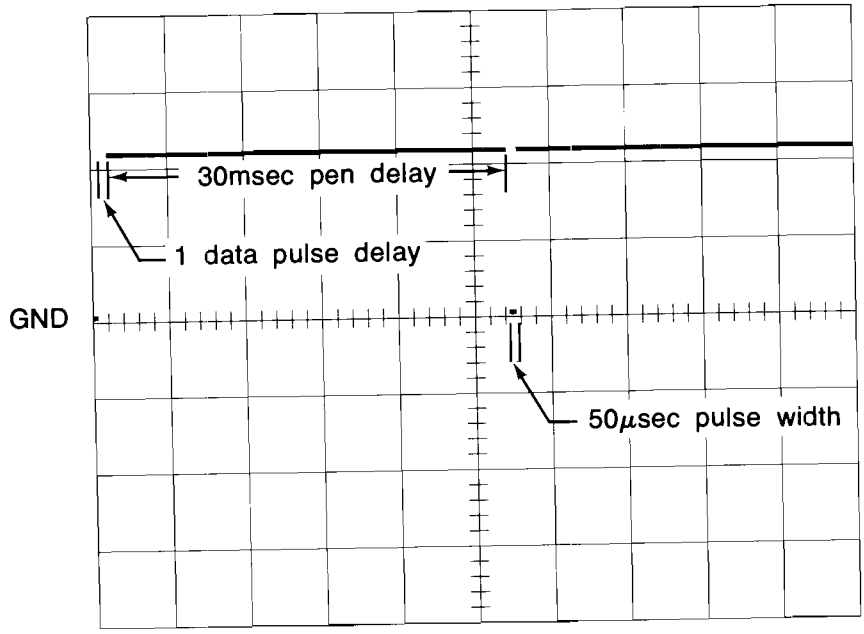


Figure 3-5:

Pen Up/Pen Dn Display

The high level of the wave form is the data pulse delay followed by the pen up or pen down delay. The low level is either a 20μsec or 50μsec pulse depending upon the setting of the pulse width switch (S1-9).

The Latched Pen Select Lines

The latched pen select lines (pen #1 thru pen #) should all have identical wave forms for specific switch settings. These lines all have TTL output voltage levels (0v to +5v) regardless of the position of the voltage select switch, S2.

The computer's pen statement causes the appropriate pen line to be driven low for the amount of time selected for the pen down delay followed by a data pulse delay (shown in Figure 3-6).

The high portion of the wave form consists of a pen down delay and a data pulse delay to unlatch the output before the next pen statement.

OSCILLOSCOPE SETTINGS

20msec/div
2V/div

INTERFACE SWITCH SETTINGS

Highest data rate (S1−1 thru S1−6 closed)
20μsec pulse width (S1−9 closed)
60msec pen dn delay (S1−8 open)

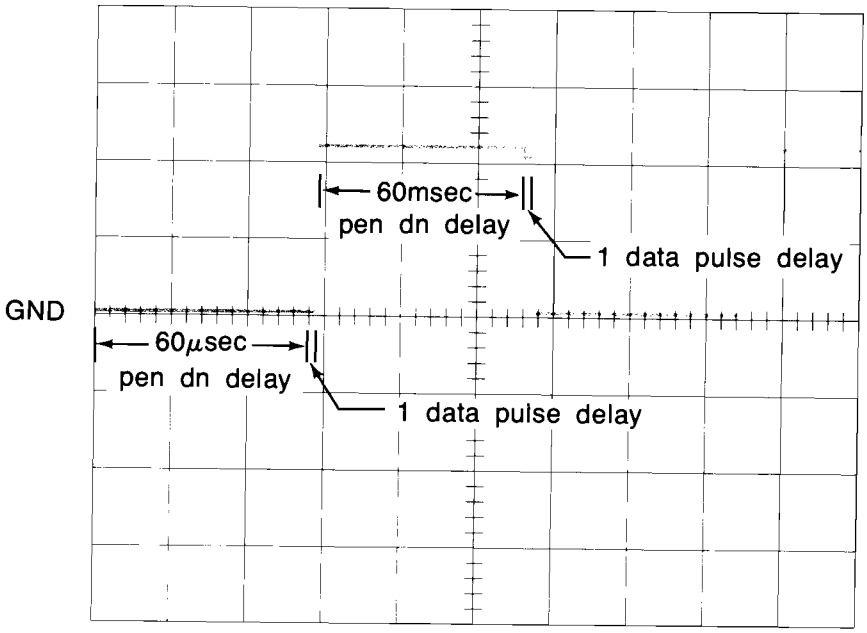


Figure 3-6:

Pen Select Display at High Data Rates

The data pulse delay is included in the pen control outputs (pen select, pen up and pen down) to allow the monostables used to trigger the pen up and pen down delays (A2U12A and A2U17A) time to recover before they are triggered again. If the data rate is relatively slow the data delays can become a significant portion of the total pulse as shown in Figure 3-7.

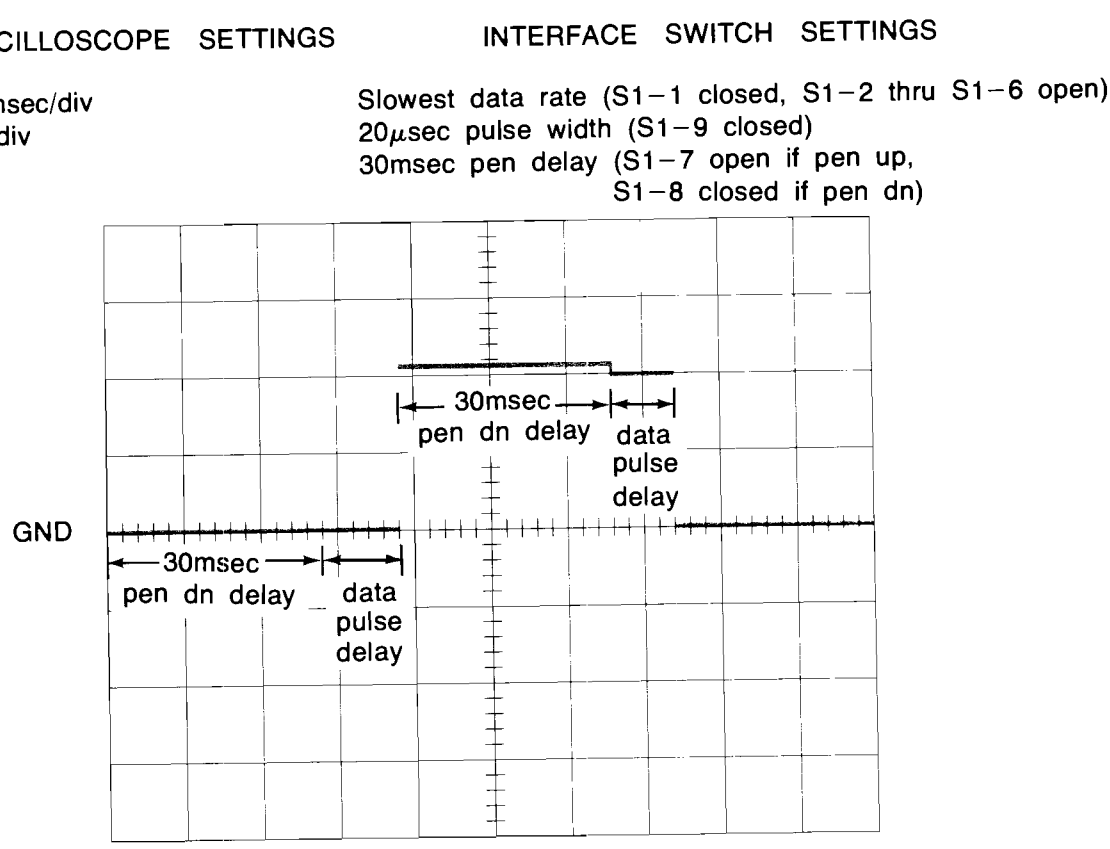


Figure 3-7:

Pen Select Display at Low Data Rates

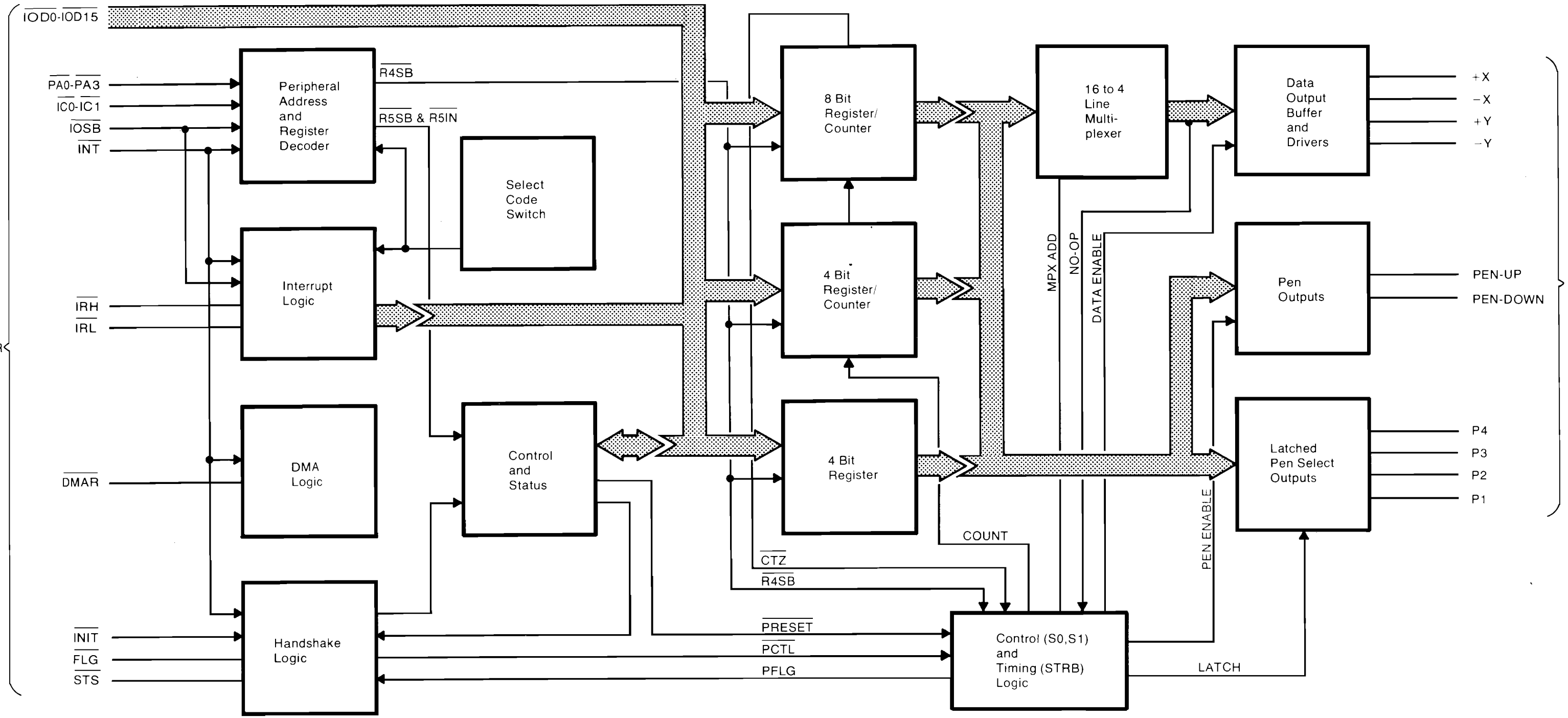
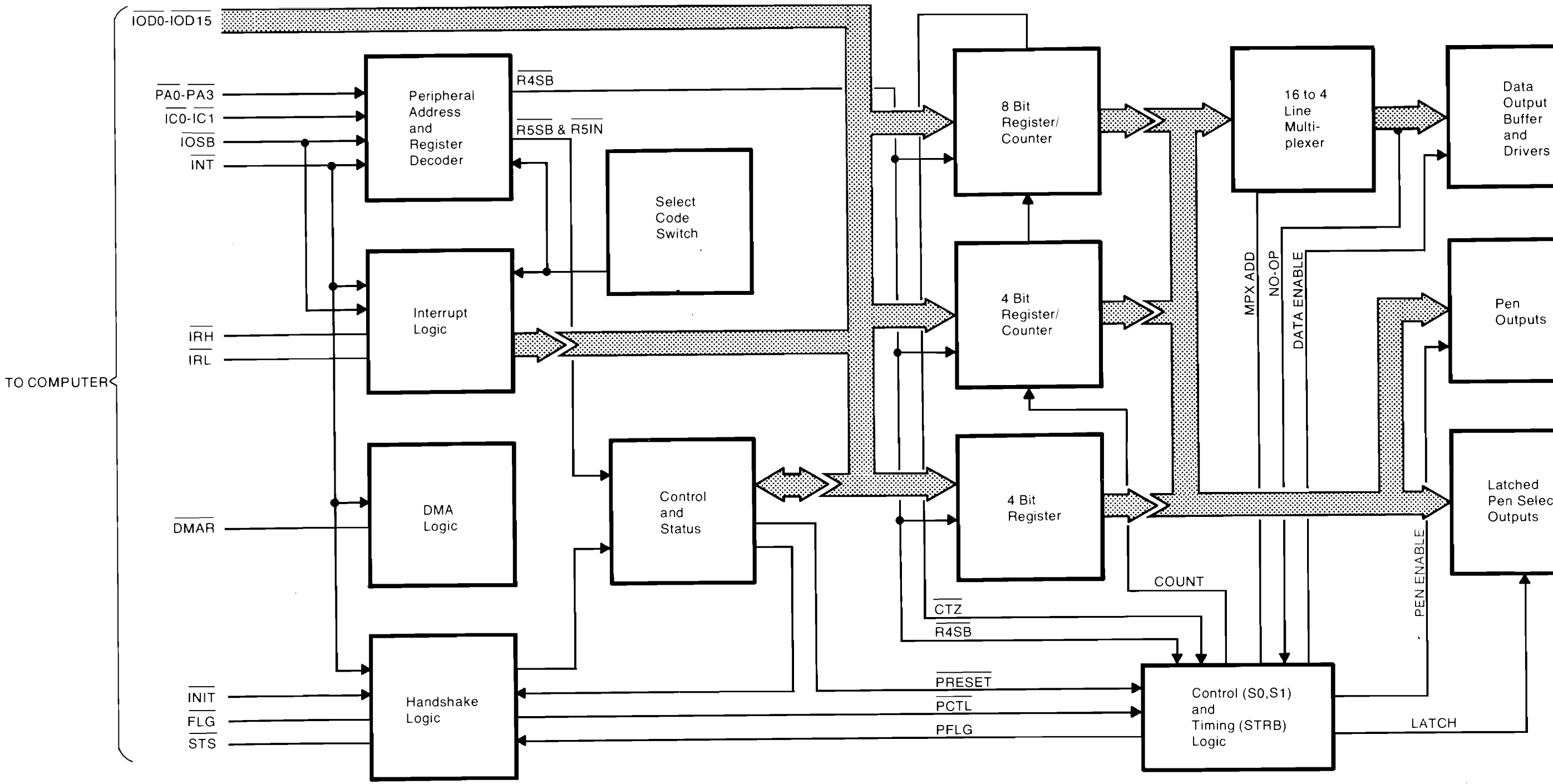
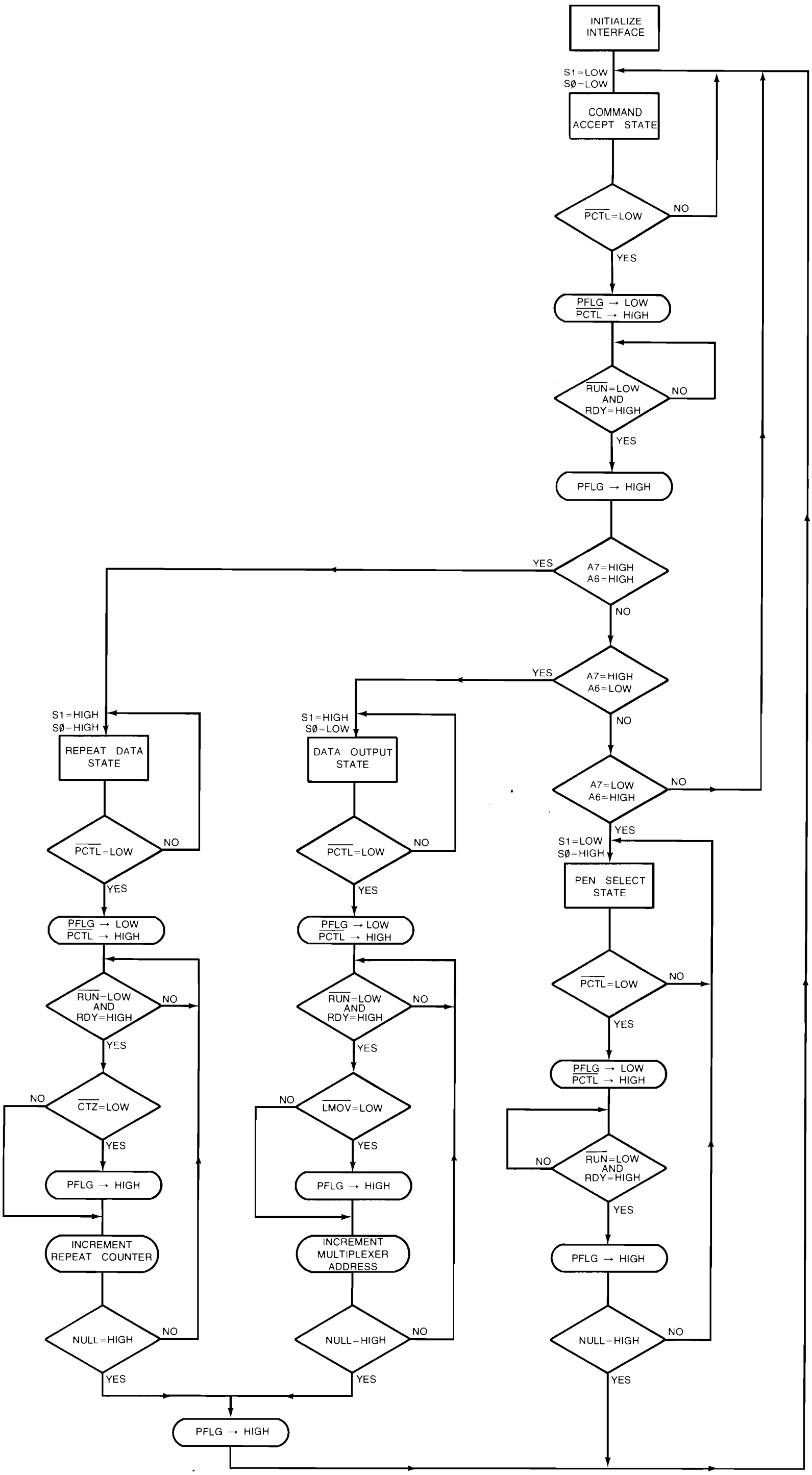


Figure 3-8:

Interface Block Diagram


IOD0-IOD15
PA0-PA3
IC0-IC1
IOSB
INT
IRH
IRL
TO COMPUTER
DMAR
INIT
FLG
STS
Peripheral Address and Register Decoder
R4SB
R5SB & R5IN
Select Code Switch
Interrupt Logic
DMA Logic
Control and Status
Handshake Logic
8 Bit Register/ Counter
4 Bit Register/ Counter
4 Bit Register
16 to 4 Line Multi-plexer
Data Output Buffer and Drivers
Pen Outputs
Latched Pen Select Outputs
MPX ADD
NO-OP
DATA ENABLE
PEN ENABLE
COUNT
CTZ
R4SB
PRESET
PCTL
PFLG
Control (S0,S1) and Timing (STRB) Logic
LATCH


INITIALIZE INTERFACE
S1=LOW SØ=LOW
COMMAND ACCEPT STATE
PCTL=LOW
NO
YES
PFLG → LOW
PCTL → HIGH
RUN=LOW AND RDY=HIGH
NO
YES
PFLG → HIGH
A7=HIGH A6=HIGH
YES
NO
A7=HIGH A6=LOW
YES
NO
A7=LOW A6=HIGH
NO
YES
S1=HIGH SØ=HIGH
REPEAT DATA STATE
PCTL=LOW
NO
YES
PFLG → LOW
PCTL → HIGH
RUN=LOW AND RDY=HIGH
NO
YES
CTZ=LOW
NO
YES
PFLG → HIGH
INCREMENT REPEAT COUNTER
NULL=HIGH
NO
YES
S1=HIGH SØ=LOW
DATA OUTPUT STATE
PCTL=LOW
NO
YES
PFLG → LOW
PCTL → HIGH
RUN=LOW AND RDY=HIGH
NO
YES
LMOV=LOW
NO
YES
PFLG → HIGH
INCREMENT MULTIPLEXER ADDRESS
NULL=HIGH
NO
YES
S1=LOW SØ=HIGH
PEN SELECT STATE
PCTL=LOW
NO
YES
PFLG → LOW
PCTL → HIGH
RUN=LOW AND RDY=HIGH
NO
YES
PFLG → HIGH
NULL=HIGH
NO
YES
PFLG → HIGH

Replaceable Parts

	Reference Designator	HP Part No.		TQ	Description
	A1	98040-66501			I/O Control Assembly
	C1	0180-0106		1	C-F 60μf 6v
	C2 thru C5	0160-4084		4	C-F .1μf 50v
	C6	0160-0938		1	C-F 1000pf 100v
	C7	0140-0206		1	C-F 270pf 500v
	R1, R2	0757-0442		2	R-F 10K 1%
	R3, R4	1810-0136		2	R-Network
	S1	3100-3364		1	Select Code Switch
	U1	1820-1427		2	IC: SN74LS156
	U2	1820-1197		2	IC: 74LS00N
	U3	1820-1198		1	IC: SN74LS03N
	U4	1820-1297		1	IC: 74LS266
	U5	1820-1112		3	IC: 74LS74
	U6	1820-1144		1	IC: SN74LS02N
	U7	1820-1201		1	IC: SN74LS08N
	U8	1820-1491		1	IC: SN74LS367N
	U9	1820-1203		1	IC: SN74LS11N
	U10	1820-1199		1	IC: 74LS04N
	U11	1820-1112			IC: 74LS74
	U12	1820-1208		1	IC: SN74LS32
	U13	1820-1427			IC: SN74LS156
	U14	1820-1112			IC: 74LS74
	U15	1820-1197			IC: 74LS00N
	Ul6	1820-1211		1	IC: SN74LS86N
	U17	1820-1423		1	IC: SN74LS123N
	U18	1820-0471		1	IC: SN7406N
	XA2	1251-4215		1	6 Socket Connector
	XA2	1251-4217		2	15 Socket Connector

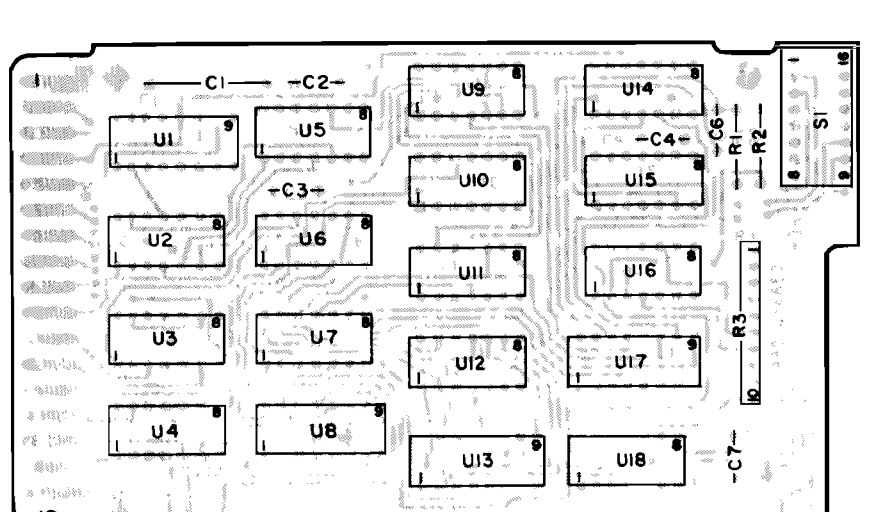
	Reference Designator	HP Part No.		TQ	Description
	A2	98040-66502			Data Control Assembly
	C1	0180-0106		1	C-F 60μf 6v
	C2	0160-0576		1	C-F .1μf 50v
	C3, C4	0160-3847		2	C-F .01μf 50v
	C5	0180-0374		1	C-F 10μf 20v
	C6, C7	0180-1743		2	C-F .1μf 35v
	C8	0160-0153		1	C-F .001μf 200v
	C9	0160-3017		1	C-F .015μf 5%
	J1	1251-5240		1	Connector – 20 pin
	P2	1251-4326		1	Connector – 36 pin
	Q1 thru Q7	1854-0071		7	XSTR – NPN
	R1	0683-4725		3	R-F 4700 5%
	R2, R3	0757-0476		2	R-F 301k 1%
	R4	0698-3228		1	R-F 49.9k 1%
	R5, R6	0698-8344		2	R-F 604k 1%
	R7	0698-3157		1	R-F 19.6k 1%
	R8	0698-3499		1	R-F 40.2k 1%
	R9	0757-0463		1	R-F 82.5k 1%
	R10	0698-4522		1	R-F 165k 1%
	R11	0757-0477		1	R-F 332k 1%
	R12	0698-8347		1	R-F 665k 1%
	R13	0683-4725			R-F 4700 5%
	R14	0757-0454		1	R-F 33.2k 1%
	R15	0683-4725			R-F 4700 5%
	R16	0683-2735		1	R-F 27k 5%
	S1	3101-2102		1	Switch 10 Rocker Dip
	S2	3101-1341		1	Slide Switch
	U1	1820-1561		3	IC: MM74C193N
	U2	1820-1562		1	IC: MM74C175N
	U3	1820-1471		2	IC: MC14539BCP
	U4	1820-1576		2	IC: MM74C107
	U5, U6	1820-1561			IC: MM74C193N
	U7	1820-1471			IC: MC14539BCP
	U8	1820-1576			IC: MM74C107
	U9	1820-1753		1	IC: MM74C74N
	U10	1820-0949		1	IC: CD4011AE

Reference Designator	HP Part No.	TQ	Description
U11	1820-0948	1	IC: MC14002
U12	1820-1485	2	IC: MM74C221N
U13	1820-1145	1	IC: CD4049AE
U14	1820-0839	1	IC: 74175N
U15	1820-1365	1	IC: 74C157
U16	1820-0951	1	IC: CD4019AE
U17	1820-1485		IC: MM74C221N
	98040-61601		Cable Assembly (standard)
P1	1251-1714	1	Connector
	1251-0688	13	Connector Terminals
	1251-0352	1	Connector Cable Bushing
	1251-3808	2	Polarizing Plug
	1251-5241	1	Connector Housing
W1	5041-1407	1	Molded Cable
	98040-67901		Front Housing Assembly (includes A1 and A2)
	2200-0536	8	Screw, 4-40
	7120-6744	1	I.D. cabel
	7120-5171	1	Plate, U.S.A
	5040-8163	1	Right Case
	5040-8158	1	Spring Latch
	5040-8161	1	Left Case
	98040-67902		Rear Housing Assembly (standard)
	98040-61601	1	Cable Assembly (standard)
	2200-0510	2	Screw, 4-40
	5040-7998	1	Right Cover
	5040-8174	1	Left Cover
	7120-6745	1	I.D. Label
	98040-90000	1	Installation and Service Manual

98040-61601 Cable Assembly

PI Connector	Cable Wire Color	Output Signal	Plotter Connector
1	N/C		
2	Blu	Pen Up	11
3	Grn	Pen DN	12
4	Yel	+X	6
5	Orn	−X	5
6	Brn	+Y	7
7	Red	−Y	8
8		PEN 1	Special Option Only
9		PEN 3	Special Option Only
10	N/C		
11	Shield		
12	Wht		15
13	Wht		15
14	Wht		15
15	Wht		15
16	Wht		15
17	Wht		15
18		PEN 2	Special Option Only
19		PEN 4	Special Option Only
20	N/C		

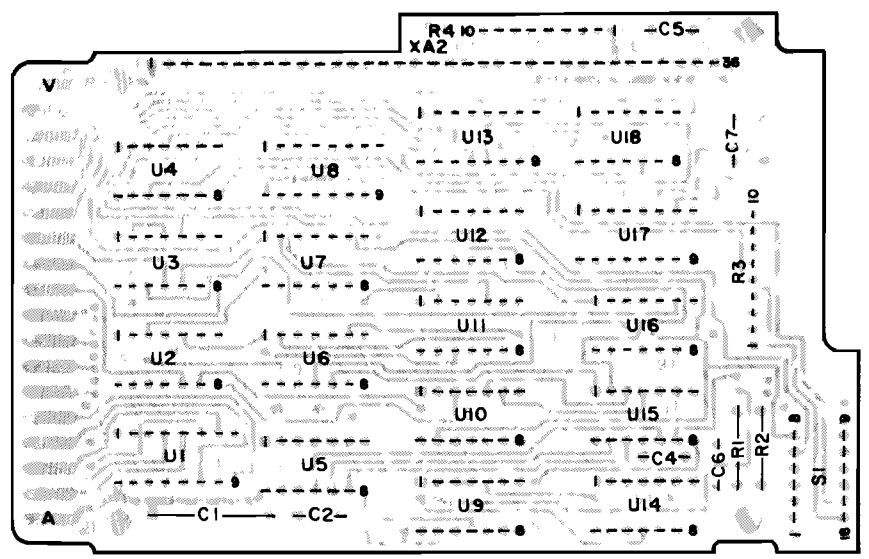
A1 COMPONENT LOCATORS



COMPONENT SIDE

A1

-hp- Part No. 98040-66501 Rev A

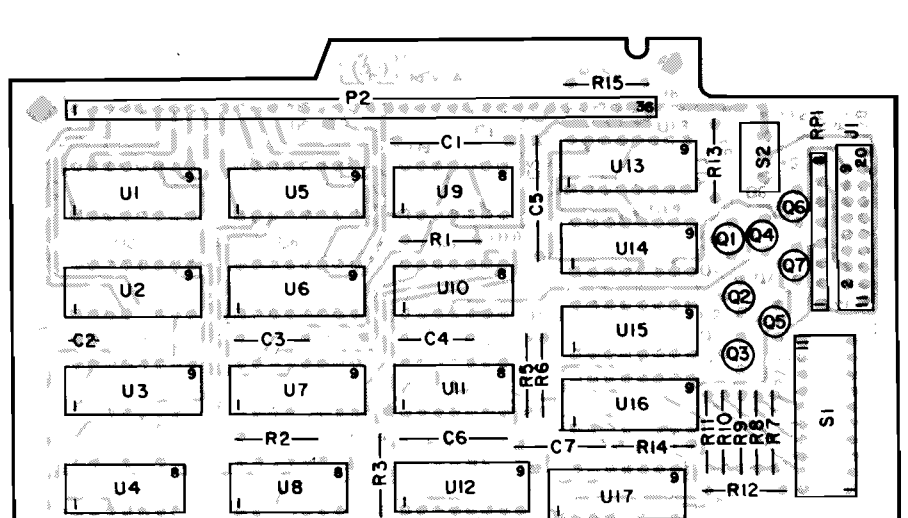


CIRCUIT SIDE

A1

-hp- Part No. 98040-66501 Rev A

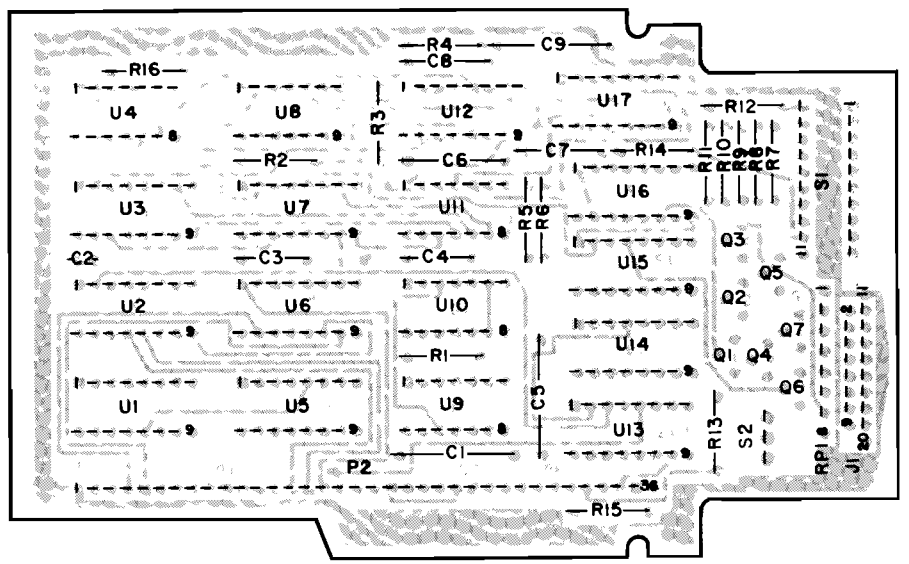
A2 COMPONENT LOCATORS



COMPONENT SIDE

A2

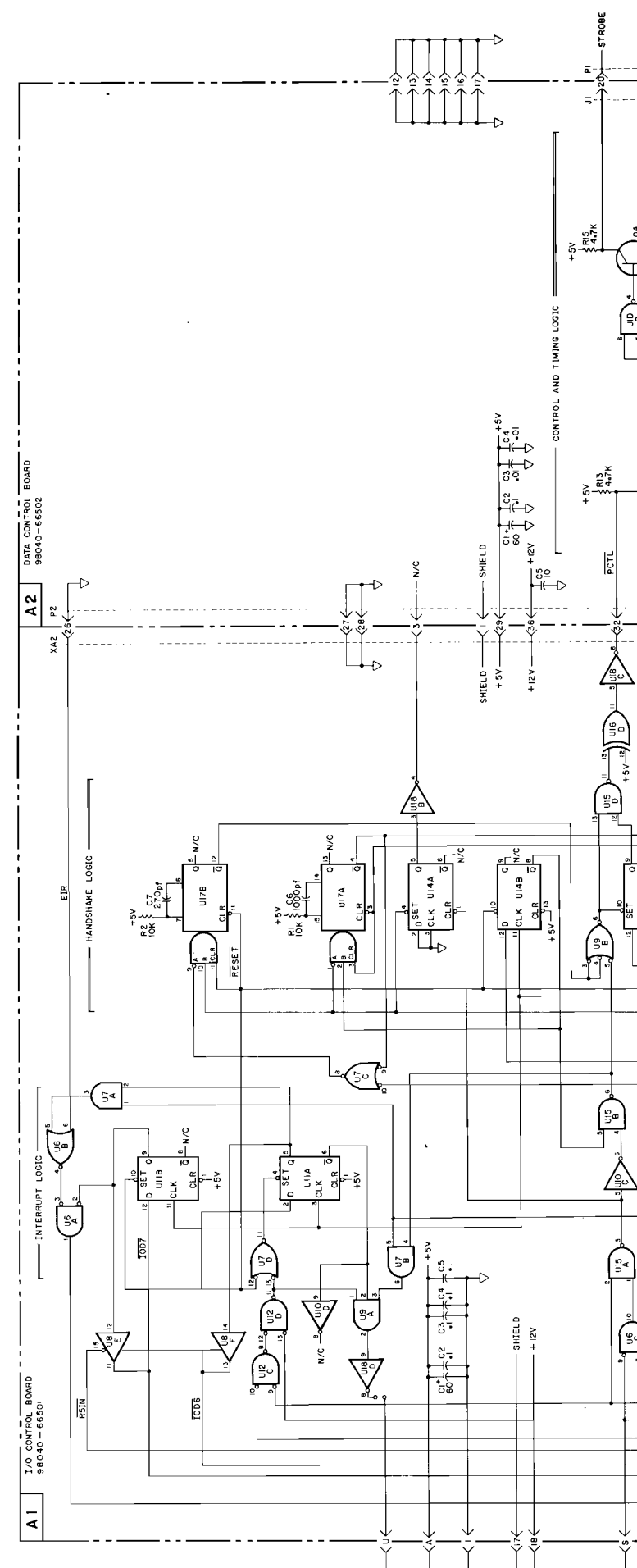
-hp- Part No. 98040-66502 Rev A



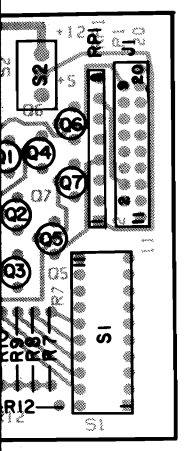
CIRCUIT SIDE

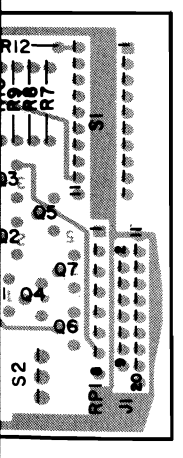
A2

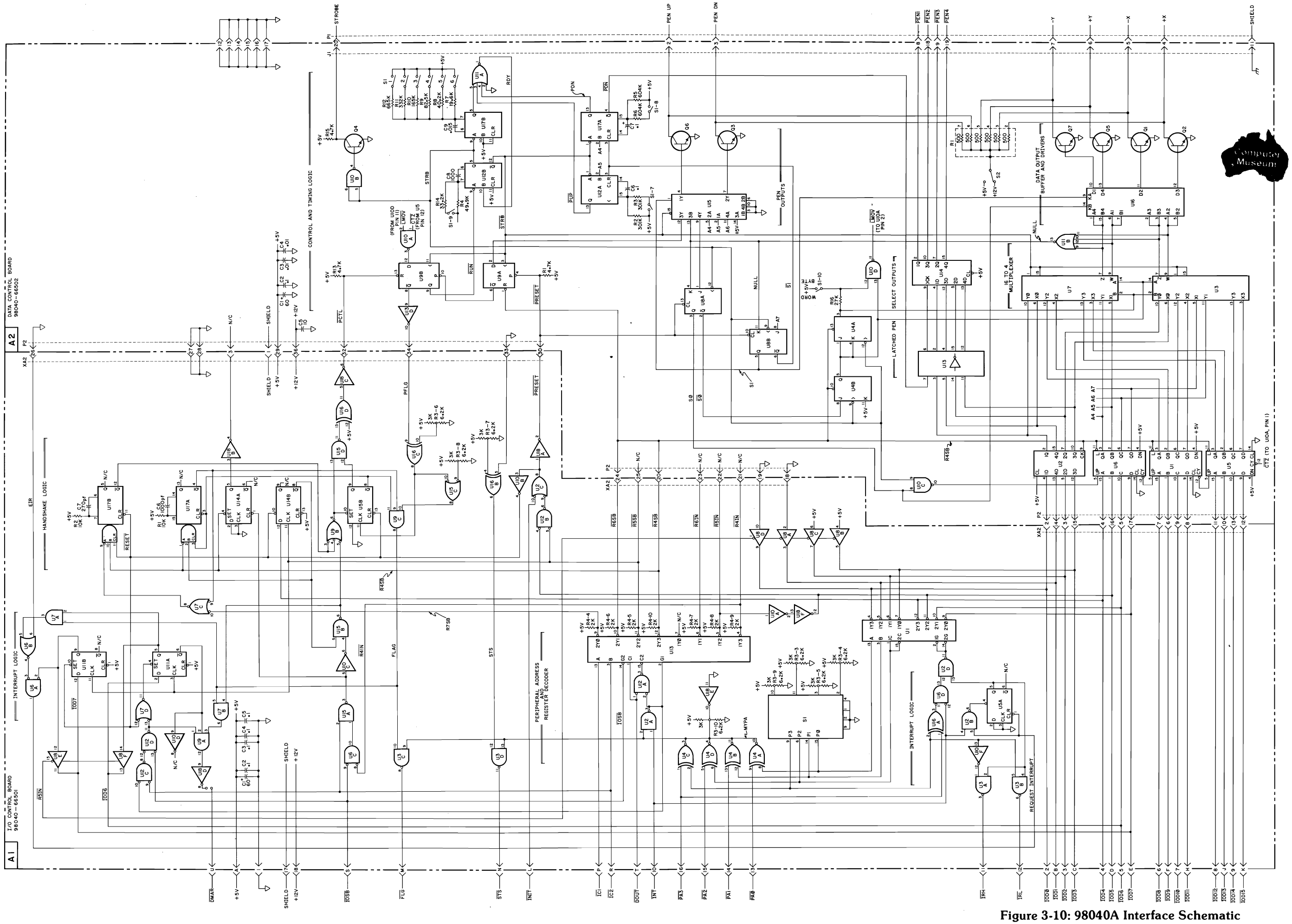
-hp- Part No. 98040-66502 Rev A



RS







98040A-J-51295

Figure 3-10: 98040A Interface Schematic

Appendix

Pen Selection Procedure

The selection of pens on multiple pen plotters equiped with the standard eight vector interface and pulsed pen up and pen down signals, typically requires a sequence of data output signals. This sequence of signals may require any combination of the drive lines and pen up and pen down lines to be pulsed simultaneously. This capability has been provided in the 98040A hardware, and is utilized by the 9845A GRAPHICS ROM to select pens on certain plotters (Houston DP-8S3, ZETA 3600).

It is possible to select pens on other multiple pen plotters if pen selection can be accomplished by a sequence of output pulses. Implementation of a pen selection routine requires that you know the output pulse sequence required for selecting pens on your plotter.

The following steps can be followed to obtain the decimal equivalent values of the data bytes that can be sent to the interface from a subprogram to pulse the proper sequence of output lines that will select the desired pen on the plotter.

Step 1:

> Define the sequence of output lines that, when pulsed, will select a pen. This can be done by entering the value (shown in parenthesis) for each output line in the table in Figure A-1, if that output line must be pulsed during the corresponding output sequence. Enter a 0 if the line is not pulsed during that sequence.

Step 2:

Add the values assigned in step 1 to each data output line for each output sequence in the table.

Output Sequence	Pen Up (32)	Pen Down (16)	+X (8)	−X (4)	+Y (2)	−Y (1)	Output Sequence Total

Figure A-1:

A Table Defining the Output Pulse Sequence.

Step 3:

Convert each output sequence total into the decimal equivalent value or values that can be sent to the interface to pulse the output lines by using the following equations

For output sequence totals of 16, 32 or 48 the decimal equivalent value is (255-total).

For all other totals **except** 16, 32 or 48, the decimal equivalent values are 191 and (255-total).

Arrange the converted decimal equivalents in the original output sequence order. The decimal equivalent value, 255, must be the first value in all sequences.

255
Output Sequence 1 decimal values
Output Sequence 2 decimal values

Repeat these three steps for each pen on the plotter.

For example, assume that a 3 pen plotter with the pen offset in the Y direction and 50mm spacing between pens, is connected to the computer by the 98040A interface. The plotter is one which does not have its pen selection sequence in the computer's Graphics or Plotter ROM.

The proper PLOTTER IS statement for this plotter would be:

```
PLOTTER IS 5, "INCREMENTAL", step size, 3, 50, 6
```

The output sequence needed to select pens for this plotter can be found by following steps 1 thru 3.

Step 1 and Step 2:

Output Sequence	Pen Up (32)	Pen Down (16)	+X (8)	−X (4)	+Y (2)	−Y (1)	Output Sequence Total
Pen 1							
1	0	0	8	4	2	1	15
2	32	0	8	0	0	0	40
3	32	16	0	0	0	0	48
Pen 2							
1	0	0	8	4	2	1	15
2	32	0	0	4	0	0	36
3	32	16	0	0	0	0	48
Pen 3							
1	0	0	8	4	2	1	15
2	32	0	0	0	2	0	34
3	32	16	0	0	0	0	48

Step 3:

The computed integer values for each output sequence would be found and organized as follows:

Pen #	Step 2 Sequence Totals	Step 3 Conversion	Sequence of Decimal Equivalent Values
Pen 1			255 (always sent first)
	15	191	191
		(255-15)	240
	40	191	191
		(255-40)	215
	48	(255-48)	207
Pen 2			255 (always sent first)
	15	191	191
		(255-15)	240
	36	191	191
		(255-36)	214
	48	(255-48)	207
Pen 3			255 (always sent first)
	15	191	191
		(255-15)	240
	34	191	191
		(255-34)	221
	48	(255-48)	207

A subroutine subprogram, which can be called by the main program toselect the desired pen, is shown next. The main program stores the number of the pen to be selected in the variable P and then calls the subprogram Pen(P).

```
90 CALL Pen(P)        !P = Pen Number
  .
  .
  .
  .
  .
290 END
300 SUB Pen(P)
310 PENUP
320 PEN P   ! Uses the Graphics or Plotter ROM
330         !Routine to offset the pen
340 PRINTER IS 5   ! Assumes that the 98040A select code is 5.
Allows the computer to send data to the 98040 via PRINT USING.

350 ON P GOTO Pen 1, Pen 2, Pen 3
360 Pen 1:  PRINT USING ""#, K'';CHR$(255),
CHR$(191), CHR$(240), CHR$(191), CHR$(215), CHR$(207)
370 GOTO EXIT
380 Pen 2:  PRINT USING ""#, K'';CHR$(255)
CHR$(191), CHR$(240), CHR$(191), CHR$(214), CHR$(207)
390 GOTO EXIT
400 Pen 3:  PRINT USING ""#, K'';CHR$(255), CHR$(191)
CHR$(240), CHR$(191), CHR$(221), CHR$(207)
410 EXIT:  PRINTER IS 16 ! Redefines printer as the CRT.
420 SUBEND
```

CALCOMP 1039 Plotter Pen Selection

This subroutine Subprogram can be used to select pens on a Calcomp 1039 Plotter.

```
300 SUB Pen(P)
310 PENUP
320 PEN P
330 PRINTER IS 5 ! The Factory Set 98040 Select Code
340 PRINT USING ""#, K'';CHR$(255), CHR$(207)
350 ON P GOTO Pen 1, Pen 2, Pen 3
360 Pen 3:   PRINT USING ""#, K''; CHR$(223), CHR$(223),
CHR$(223), CHR$(207)
370 GOTO EXIT
380 Pen 2:   PRINT USING ""#, K'';CHR$(223), CHR$(223),
CHR$(207)
390 GOTO EXIT
400 Pen 1:  PRINT USING ""#, K'';CHR$(223), CHR$(207)
410 EXIT:  PRINTER IS 16
420 SUBEND
```

System Verification Program Listing

```
Exp
10    INPUT "INCREMENT SIZE IN MILLIMETERS",B
20    INTEGER A(16380)
30    OVERLAP
40    GRAPHICS
50    GCLEAR 0
60    PLOTTER IS 5,"INCREMENTAL",B
70    LIMIT 0,172,0,140
80    SCALE -1,1,-1,1
90    PLOTTER 5 IS ON
100   MOVE -.23,0
110   FOR X=-.23 TO .23 STEP .02
120   Y=SQR(.0529-X*X)
130   DRAW X,Y
140   NEXT X
150   FOR X=.23 TO -.23 STEP -.02
160   Y=-SQR(.0529-X*X)
170   DRAW X,Y
180   NEXT X
190   MOVE -.17,.5
200   DRAW .33,.5
210   DRAW .17,-.5
220   DRAW -.33,-.5
230   DRAW -.17,.5
240   MOVE -.12,-.07
250   DRAW -.08,.17
260   MOVE -.1,.06
270   DRAW -.02,.06
280   DRAW -.04,-.07
290   MOVE 0,-.17
300   DRAW .04,.06
310   DRAW .12,.06
320   DRAW .1,-.07
330   DRAW .02,-.07
340   CSIZE 10
350   MOVE -.99,-.1
360   LABEL USING "#,7A";"HEWLETT"
370   MOVE .32,-.1
380   LABEL USING "#,7A";"PACKARD"
390   MOVE 1,-1
400   GCLEAR
410   STOP

420   END
```

Diagnostic Test Program Listing

```
10   PRINTER IS 16
20   PRINT CHR$(12);"98040A EXERCISER"
30   PRINT "PRESS KEYS SHOWN TO ACTIVATE EACH LINE"
40   PRINT "KEY 0  PEN 1","KEY 1  PEN 2","KEY 2  PEN 3","KEY 3  PEN 4",
"KEY 4  PEN UP","KEY 5  PEN DN"
50   PRINT "SHIFT Key 0  +X","SHIFT Key 1  -X","SHIFT Key 2  +Y","SHIFT
Key 3  -  Y"
60   ON KEY #0 GOTO Key0
70   ON KEY #1 GOTO Key1
80   ON KEY #2 GOTO Key2
90   ON KEY #3 GOTO Key3
100  ON KEY #4 GOTO Key4
110  ON KEY #5 GOTO Key5
120  ON KEY #16 GOTO Skey0
130  ON KEY #17 GOTO Skey1
140  ON KEY #18 GOTO Skey2
150  ON KEY #19 GOTO Skey3
160  PRINTER IS 5
170  OVERLAP
180 Key0: Key$="PEN 1"
190  GOSUB Disp
200 Pen1: PRINT USING "#,K";CHR$(255),CHR$(238),CHR$(255),CHR$(239)
210  GOTO 200
220 Key1: Key$="PEN 2"
230  GOSUB Disp
240 Pen2: PRINT USING "#,K";CHR$(255),CHR$(237),CHR$(255),CHR$(239)
250  GOTO 240
260 Key2: Key$="PEN 3"
270  GOSUB Disp
280 Pen3: PRINT USING "#,K";CHR$(255),CHR$(235),CHR$(255),CHR$(239)
290 GOTO 280
300 Key3: Key$="PEN 4"
310  GOSUB Disp
320 Pen4: PRINT USING "#,K";CHR$(255),CHR$(231),CHR$(255),CHR$(239)
330 GOTO 320
340 Key4: Key$="PEN UP"
350  GOSUB Disp
360 Penup: PRINT USING "#,K";CHR$(255),CHR$(223)
370  GOTO 360
380 Key5: Key$="PEN DN"
390  GOSUB Disp
400 Pendn: PRINT USING "#,K";CHR$(255),CHR$(239)
410  GOTO 400
420 Skey0: Key$="+X"
430  GOSUB Disp
440  PRINT USING "#,K";CHR$(255),CHR$(63)
450 Plusx: PRINT USING "#,K";CHR$(247)
460  GOTO 450
470 Skey1: Key$="-X"
480  GOSUB Disp
490  PRINT USING "#,K";CHR$(255),CHR$(63)
```

```
500 Minx: PRINT USING "#,K";CHR$(251)
510  GOTO 500
520 Skey2:Key$="+Y"
530  GOSUB Disp
540 PRINT USING "#,K";CHR$(255),CHR$(63)
550 Plusy:PRINT USING "#,K";CHR$(253)
560  GOTO 550
570 Skey3: Key$="-Y"
580  GOSUB Disp
590  PRINT USING "#,K";CHR$(255),CHR$(63)
600 Miny: PRINT USING "#,K";CHR$(254)
610  GOTO 600
620 Disp: DISP Key$;" NOW BEING PULSED"
630  RETURN
640  END
```

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