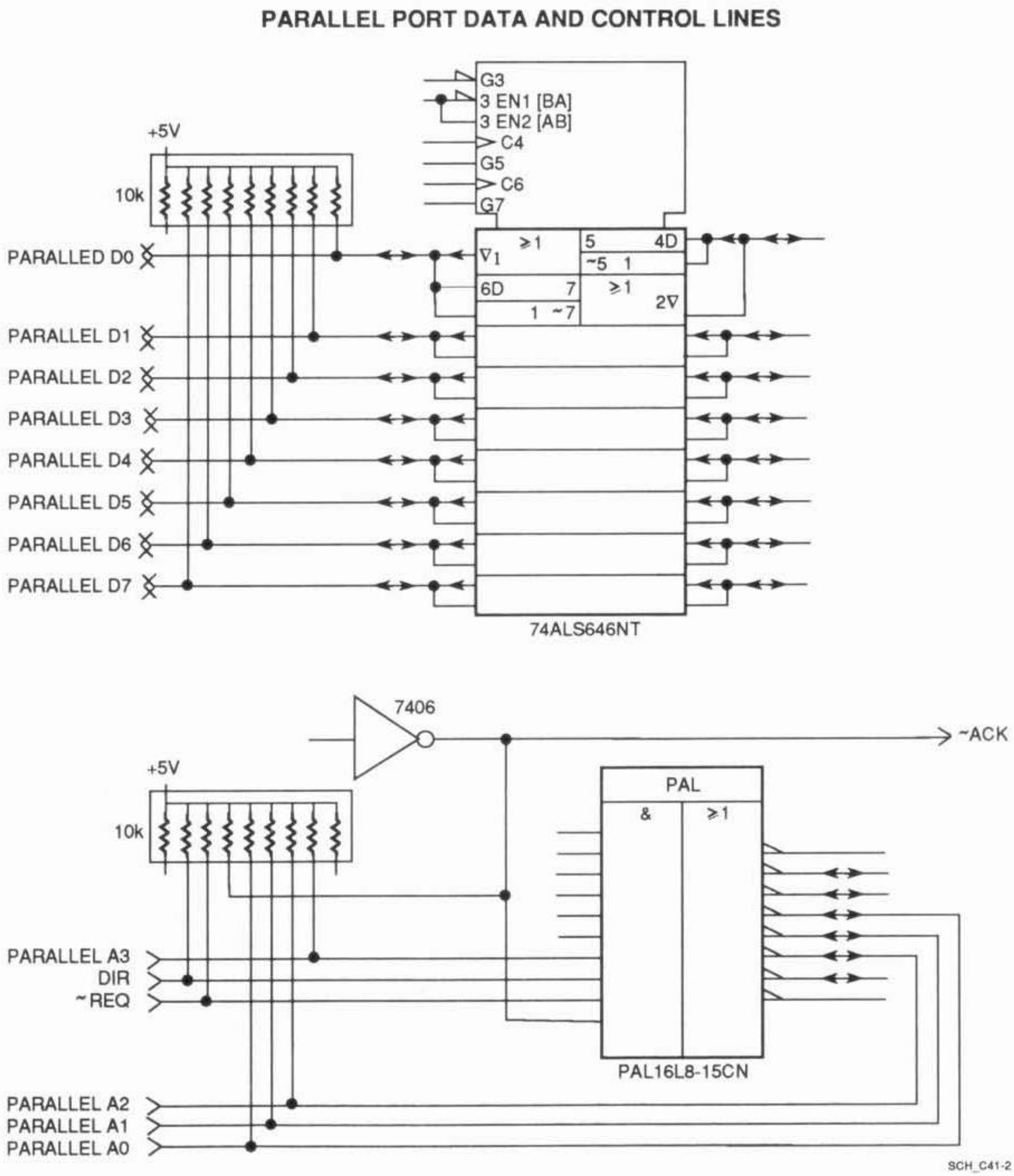


Figure 3-15g. HP 10934A I/O Schematic Diagram (continued)

Connecting the 8-Bit Parallel Port To An HP 98622A GPIO Interface

The HP 98622A GPIO Interface provides a 16-bit input/output port to the HP 9000 Series 200/300 computers. The configuration switches for the interface should be set as follows:

PCTL	1	LO BYTE RD	1
PFLG	0	LO BYTE BSY	0
PSTS	1	LO BYTE RDY	1
HSHK	1	HI BYTE RD	1
D_IN	0	HI BYTE BSY	0
D_OUT	0	HI BYTE RDY	1

Connect the HP 10934A's 8-bit parallel port lines to the HP 98622A as indicated by the following wire/pinout listing:

HP 10934A signal name		HP 10934A pin #	HP 98622A Opt 001 cable wire color	HP 98622A pin #	HP 98622A signal name
	REQ-	25	WHT/GRA	19	PCTL
	ACK-	50	GRA	44	PFLG
	DIR	49	WHT/BLK/BRN	20	I/O
Par.	Gnd	24	WHT,WHT/BLK/ORN-//BLU (two)	1,18,24,26,49	GND
Par.	D0	48	WHT/BLK and BLK (both)	17 & 42	DO0 & DI0
Par.	D1	47	WHT/BRN and BRN (both)	16 & 41	DO1 & DI1
Par.	D2	46	WHT/RED and RED (both)	15 & 40	DO2 & DI2
Par.	D3	45	WHT/ORN and ORN (both)	14 & 39	DO3 & DI3
Par.	D4	50	WHT/YEL and YEL (both)	13 & 38	DO4 & DI4
Par.	D5	21	WHT/GRN and GRN (both)	12 & 37	DO5 & DI5
Par.	D6	22	WHT/BLU and BLU (both)	11 & 36	DO6 & DI6
Par.	D7	23	WHT/VIO and VIO (both)	10 & 35	DO7 & DI7
Par.	A0	44	WHT/ORN/YEL	9	DO8
Par.	A1	43	WHT/ORN/GRN	8	DO9
Par.	A2	18	WHT/ORN/BLU	7	DO10
Par.	A3	19	WHT/ORN/VIO	6	DO11

The following BASIC program code segments give an example of how to use the above connection for data transfer.

```
WRITING DATA:!

OPTION BASE 1
DIM Output_string$[80]
INTEGER Send(80)
Addr=256*5                        ! parallel port address (5 = "X" in mainframe 0)
Gpio=12                           ! interface select code address
ASSIGN @Io to Gpio;FORMAT OFF,EOL OFF,WORD
!
Output_string$="CNFG?"            ! put desired mnemonic string between quotes.
                                  ! adjust each byte to contain parallel port address too.
FOR I=1 to LEN(Output_string$)
   Send(I)=NUM(Output_string$[I;1]+Addr
NEXT I
                                  ! adjust length of output array, append CR/LF, and output it
REDIM Send(I-1)
OUTPUT  @Io;Send(*),10+Addr,13+Addr

READING DATA:!

DIM Response$[80]
Addr=256*4                        ! parallel port address (4 = "W" in mainframe 0)
Gpio=12                           ! interface select code address
ASSIGN @Gpio to Gpio;BYTE         ! specify a byte wide data channel

CONTROL Gpio,3;255+Addr           ! set address lines and clear data lines
ENTER @Gpio;Response$             ! read input up to a CR/LF
```

BOARD EDGE

POSITION ERROR (B30)	1	26	POSITION ERROR (SIGN)
POSITION ERROR (B28)	2	27	POSITION ERROR (B29)
POSITION ERROR (B26)	3	28	POSITION ERROR (B27)
POSITION ERROR (B24)	4	29	POSITION ERROR (B25)
POSITION ERROR (B22)	5	30	POSITION ERROR (B23)
POSITION ERROR (B20)	6	31	POSITION ERROR (B21)
POSITION ERROR (B18)	7	32	POSITION ERROR (B19)
POSITION ERROR (B16)	8	33	POSITION ERROR (B17)
POSITION ERROR (B14)	9	34	POSITION ERROR (B15)
POSITION ERROR (B12)	10	35	POSITION ERROR (B13)
POSITION ERROR (B10)	11	36	POSITION ERROR (B11)
POSITION ERROR (B8)	12	37	POSITION ERROR (B9)
POSITION ERROR (B6)	13	38	POSITION ERROR (B7)
POSITION ERROR (B4)	14	39	POSITION ERROR (B5)
POSITION ERROR (B2)	15	40	POSITION ERROR (B3)
POSITION ERROR (B0)	16	41	POSITION ERROR (B1)
GROUND	17	42	GROUND
ERROR CLOCK	18	43	POSITION NULL
GROUND	19	44	GROUND
DRIVE ENABLE OUT-	20	45	DRIVE ENABLE IN-
GROUND	21	46	GROUND
POSITION RESET-	22	47	EXTERNAL SAMPLE-
GROUND	23	48	GROUND
DESTINATION WRITE-	24	49	ANALOG VELOCITY
TCP/SMG-	25	50	ANALOG GROUND

Figure 3-16. Inter-Card Connector Pinouts

DESTINATION WRITE- OUTPUT

The Destination Write- Output is a decoded write pulse which strobes a new destination value into the Position Error subtractor. It is an active-low output approximately 260 nanoseconds long and may be used to signal other circuitry that the stage may be starting to slew to a new position. The Destination Write- Output is not present on the rear panel and can drive 8 LSTTL loads.

TCP/SMG- OUTPUT

This line indicates the position error output data format. TTL high (+3V) indicates two's complement coding and low (0V) indicates sign-magnitude. It is unbuffered and can drive only 2 LSTTL loads.

HP 10936A SERVO-AXIS BOARD

The HP 10936A Servo-Axis board has three main functions. First it is a 16-bit binary interface to the HP 5507A. Second, it monitors a measurement and reference signal to keep track of position. Third, it uses this position information and software-programmable servo constants to generate motor drive signals that close the feedback loop through an external power amplifier.

The 16-bit binary interface connects directly to an HP 9000 Series 200/300 Computer's GPIO interface. It has access to all boards in an HP 5507A. Thus, communication to and from any board is through either a Servo-Axis board's 16-bit interface, or the HP 5507A's HP-IB interface.

The position monitoring hardware is identical to that on an HP 10932A Axis board. Either an HP 10780B Receiver, or the measurement channel of an HP 5518A Laser Head generates the measurement signal. The reference signal is routed from the laser head to the Servo-Axis board through the HP-IB board's reference circuits and the HP 5507A's backplane. Position information is available through one of the two computer interfaces (HP-IB or binary), or through one of the motor drive outputs (requires appropriate servo constants).

Three motor drive outputs can be produced: ±10V analog, pulse width modulated, and 16-bit digital. All are the result of subtracting the current position from the reference position, applying a difference equation, adding feedforward terms, and comparing the result against a programmable maximum drive value. Reference positions are downloaded, or generated by the Servo-Axis board based on the programmed destination, velocity, acceleration, and delta acceleration. The difference equation is either a Proportional-Integral-Differential algorithm (PID), an Infinite Impulse Response Filter (IIR), or downloaded 68020 code. Additionally, four parameters (reference position, actual position, difference equation output, and motor drive) may be captured in real time, transferred to a computer, and used to optimize servo performance.

The address of the Servo-Axis board may be set to S, T, U, V, W, X, Y, or Z by setting a DIP switch at the top of the board as shown in *Figure 3-4*. Each Servo-Axis board must be set to a unique address for proper operation (throughout this section, the "*" preceding an HP-IB mnemonic represents the address selected by this DIP switch).

The extra switches are used to enter various service modes and must be in the off (zero) position for normal operation.

BASIC OPERATION

The Servo-Axis board consists of eight functional blocks:

- 16-Bit Binary Interface
- Mailbox
- Backplane Controller
- Resolution Extension IC
- Counter/Subtractor IC
- Master/Slave Logic
- Microprocessor
- Motor Drive Outputs

The 16-bit binary interface allows fast communication (commands and data) with the system control computer.

The mailbox, a dual port RAM, is used by a backplane controller to send commands to this board, and read data from it (see HP 5507A Backplane Basics on page 3-1).

The backplane controller is used when the Servo-Axis board receives a command for another board over the binary interface, or during a coordinated multiaxis move when this board is the master.

The resolution extension IC derives the 5 least-significant-bits of the measurement, and up/down information from the measurement and reference signals. A clock and these seven output lines are routed to the counter/subtractor IC.

The counter/subtractor IC uses the information generated by the resolution extension IC to count an additional 26 bits of position. The resulting 31-bit position is available to the microprocessor. This IC also subtracts a 31-bit marker position from the position and uses the result to drive the Threshold and Window outputs.

The Maseter/Slave logic generates or receives the servo sample clock and sync signals used for coordinated multiaxis moves.

The onboard microprocessor ties all the functional blocks together. It continuously

reads the position and converts it to the programmed units,
checks for any errors,
checks for and executes any commands input through the mailbox, and
checks for and executes any commands input over the binary interface.

The microprocessor also calculates the reference position and motor drive output once per servo sample period. These calculations use the programmed motion parameters, difference equation, servo coefficients, and feedforward terms. Additionally, it will store selected values in memory each servo sample period.

The motor drive outputs convert the calculated 16-bit drive value into either a ±10 volt analog voltage, or an up/down pulse of variable duration. These outputs then drive an appropriate external power amplifier.

Figure 3-16a illustrates the Servo-Axis board's closed-loop structure in a typical application.

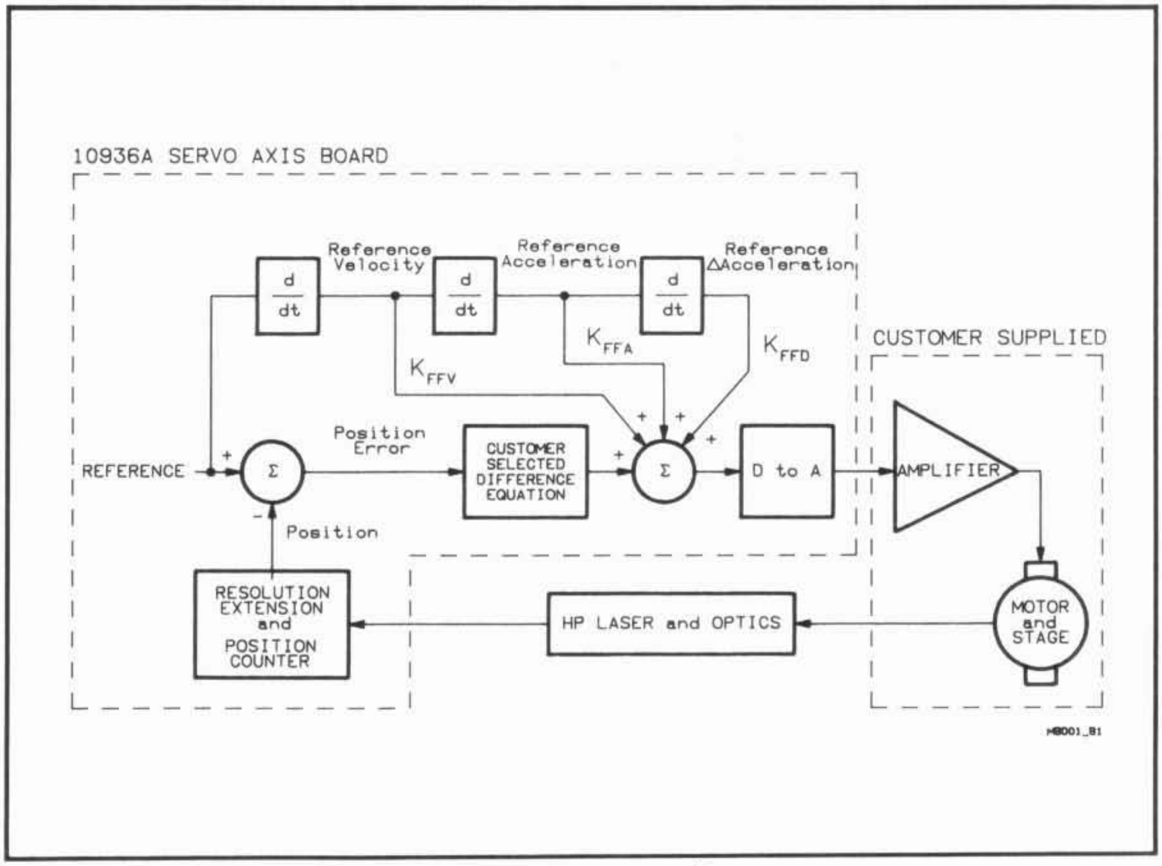


Figure 3-16a. Servo-Axis Board Structure

BINARY INTERFACE TRANSFER RATES

The binary interface's maximum burst transfer rate is 35k words per second. The data rate in measurements per second will vary depending on data format and how busy the servo-axis board is. Rates will be slower when the servo is turned on and the servo sample period is short (low values of *SPD). Also, accessing information on other boards will be slower than accessing information on this servo-axis board.

Rear Panel Connector

A 50 pin female connector, located on the rear panel, allows for connections to external equipment. Example mating connectors are:

Amp: Champ® Connectors (57-33500-2)
3M: Delta Ribbon Connectors
T&B: Ansley® Ribbon Connectors
TRW: TRW-57-30500-375
HP: 1251-7673 Connector and 1251-0170 Bushing

®Champ is a registered trademark of Amp
®Ansley is a registered trademark of T&B

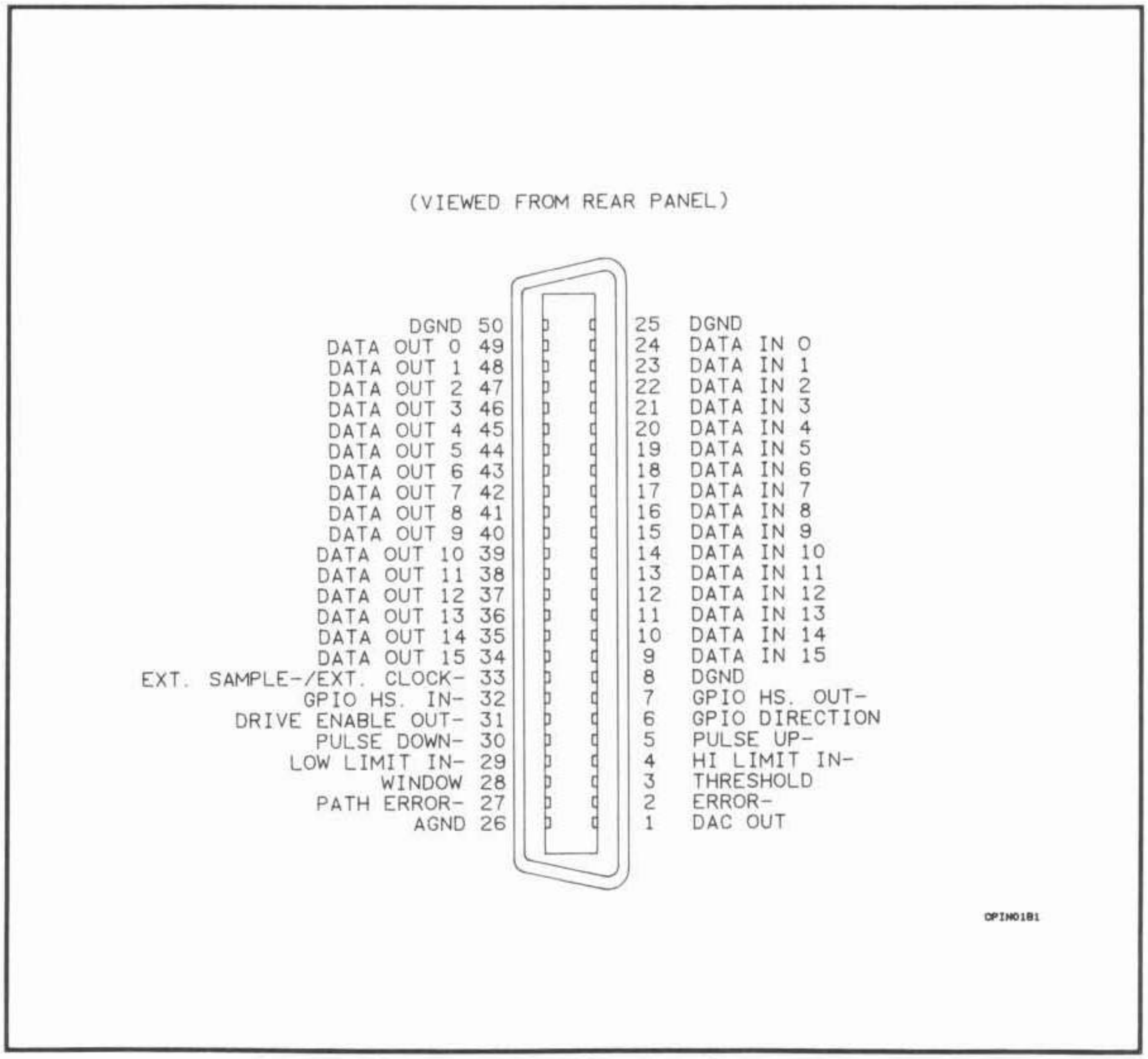


Figure 3-16b. Servo-Axis Board Rear Panel Pinout Diagram

EXTERNAL SAMPLE-/EXTERNAL SERVO CLOCK-

This input line has two functions. It is the External Servo Clock input when the servo board is programmed to use an external Servo Clock (see *SVC). Otherwise, it is the External Sample- input (see Sample Trigger Source). In either case, it presents a single TTL load to the driving signal.

HI LIMIT- and LOW LIMIT-

These inputs can be connected to mechanical limit switches on the stage to turn off the Motor Drive outputs. Their polarity is programmable (see *PTR112;*DTA), but defaults to negative true on power up or hard reset. The Motor Drive outputs will stop driving the stage in the plus direction when the Hi Limit- input goes true, and will stop driving the stage in the negative direction when the Low Limit- input goes true. Response to either of these inputs is 0.3 ms plus one Servo Sample period (set by *SPD).

These inputs may also be used as general purpose TTL level inputs by disabling the limit function (bit 2 of *PTR112;*DTA) and reading their value with the *PTR113;*DTA? query.

ERROR- and PATH ERROR-

These negative true output lines indicate error conditions. They can be programmed for two modes of operation.

> In error mode 0 or 2 (*EMD0 or *EMD2) they indicate that this servo board has an Error/Path Error.
>
> In Error mode 1 or 3 (*EMD1 or *EMD3) they indicate that some board in the HP 5507A has an Error/Path Error.

In either case, they will stay true (low) until a soft reset is executed.

THRESHOLD and WINDOW

The Threshold output goes true (high) when the stage equals or exceeds a programmed value (*MKR). The Window output goes true (high) when the stage is within a specified distance (*MKW) of the *MKR value. Response to either of these conditions is within 2 microseconds.

DRIVE ENABLE OUT-

The Drive Enable Out- line may be used to disable the stage's power amp (all Motor Drive outputs are zero when this line is high) in case of measurement errors. The following conditions force Drive Enable Out- false (high):

a. Power-up initialization or system BOOT command.

b. A drive off command (*DRE0).

c. A measurement error on this axis.

d. Position counter over/underflow error on this axis.

e. If in Error Mode 1 (*EMD1 or *EMD3), any other system or programming error.

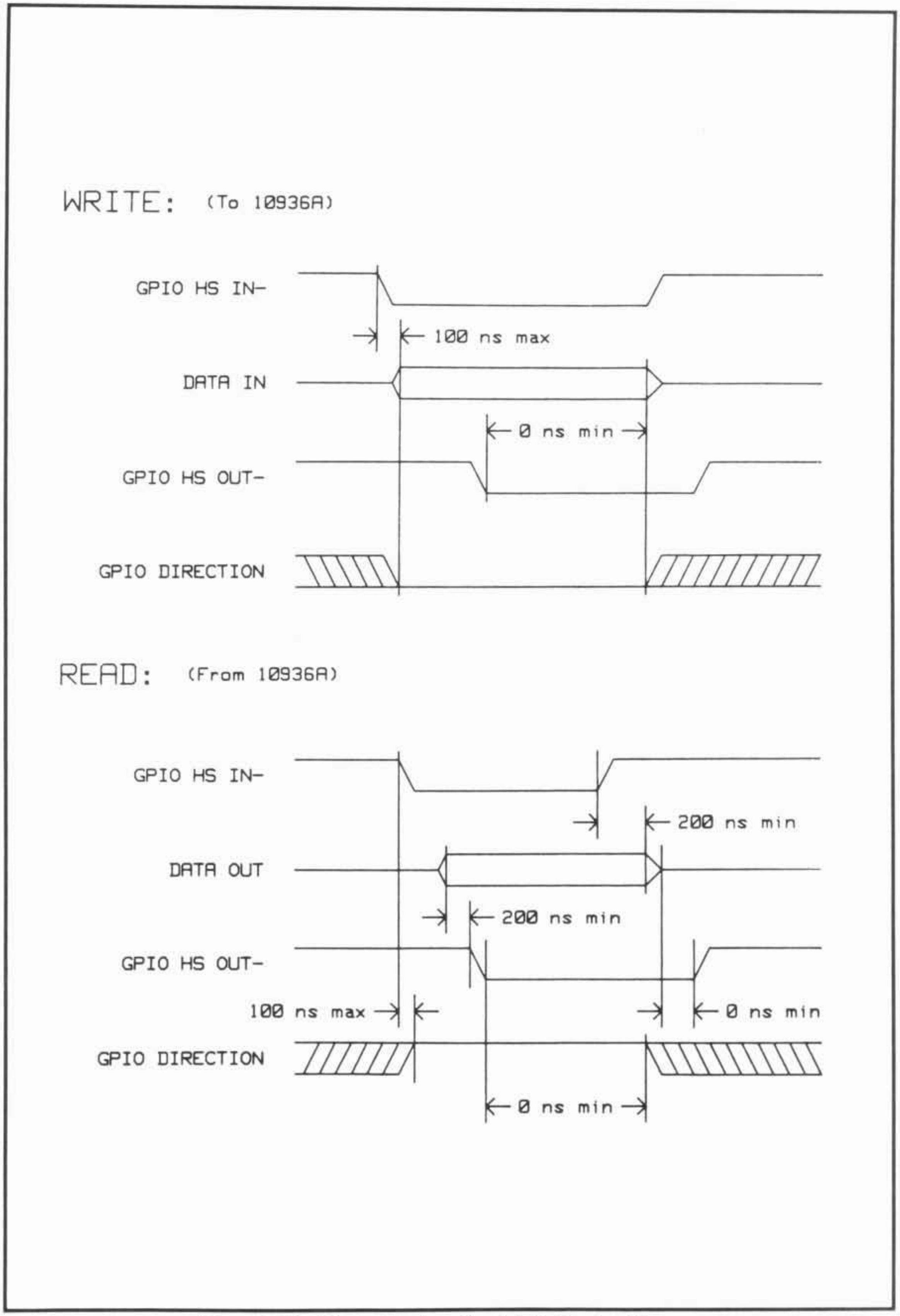


Figure 3-16c. Binary Interface Handshake Timing Diagram

DAC OUT and AGND

This is the analog Motor Drive output. It is a ±10 V signal derived from the selected difference equation and the programmed coefficients. Maximum current drain is 10 milliamperes, so a power amp must be connected between this signal and the stage motor (there is a 100 ohm series resistor in this line). This Motor Drive output is selected by setting bit 0 of the *OUT mnemonic (e.g., OUTPUT 703; XOUT 1).

PULSE UP- and PULSE DOWN-

These are the Motor Drive outputs for the pulse-width modulated output. The frequency is programmable between 250 Hz and 8 kHz, and the pulse width is derived from the selected difference equation and the programmed coefficients. Timing resolution is 125 nanoseconds, so the dynamic range and scaling depend on the frequency programmed (*SPD).

This Motor Drive output is selected by setting bit 1 of the *OUT mnemonic. (e,g,. OUTPUT 703; "XOUT 2")

DATA OUT 0 through 15

These 16 data lines are for outputting data from the Servo-Axis board to either a 16-bit interface in the control computer, or a 16-bit DAC for a Motor Drive signal. Setting bit 2 of the *OUT mnemonic selects the latter. The Data In and Data Out lines may be tied together for interfaces that use 16 I/O lines as opposed to separate input and output lines.

DATA IN 0 through 15

These 16 data lines are for inputting data and commands to the Servo-Axis board from a 16-bit interface in the control computer. The Data In and Data Out lines may be tied together for interfaces that use 16 I/O lines as opposed to separate input and output lines.

GPIO DIRECTION, GPIO HS IN- and GPIO HS OUT-

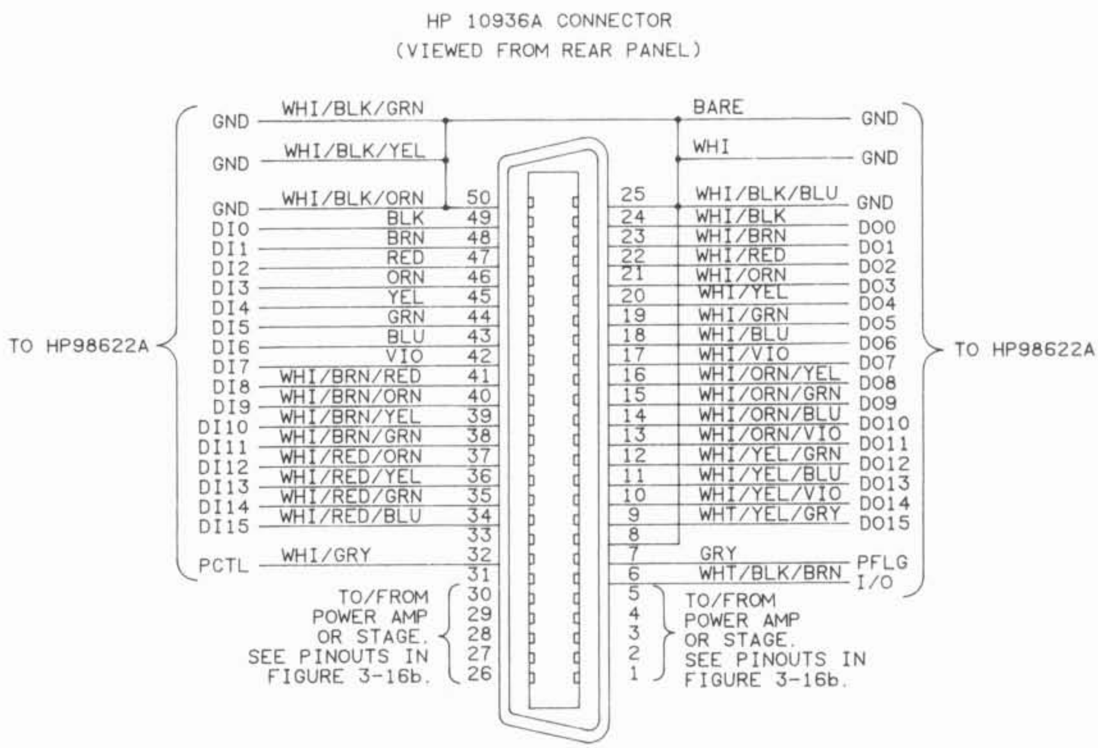
These are the handshake lines for synchronizing data transfers over the above data lines with a 16-bit interface in the control computer.

The timing diagrams in *Figure 3-16c* indicate the handshaking protocol used by these lines. They correspond directly to the handshaking lines of the HP 98622A GPIO Interface for HP 9000 series 200/300 computers. (Set PCTL, PSTS, and HSHK to 1, PFLG, DIN, and DOUT to 0, and both clocks to BSY - RD and RDY to 1, BSY to 0).

Connecting to HP 9000 Series 200/300 Computers

The binary interface on the HP 10936A Servo-Axis Board connects directly to the HP 98622A General Purpose I/O (GPIO) Interface card used in HP 9000 Series 200/300 computers. *Figure 3-16d* shows how to wire the HP 98622A Opt 001 unterminated cable to a connector for use with the Servo-Axis board. All jumpers on the interface card should be left at their factory default settings. The option and clock source switches should be set as follows:

PCTL	1	RD	1
PFLG	0	BSY	0
PSTS	1	RDY	1
HSHK	1	RD	1
D_In	0	BSY	0
D_Out	0	RDY	1



NOTES:

1. WIRE COLORS ARE FOR HP98622A OPT 001 UNTERMINATED CABLE. (IF ORDERED SEPARATELY, HP PART #5061-4209)
2. THE HP98622A GPIO INTERFACE IS A 16-BIT PARALLEL INTERFACE FOR HP9000 SERIES 200/300 COMPUTERS.

OPIH0281

Figure 3-16d. Wiring Diagram for Connection to HP 98622 GPIO Interface

Internal Inter-Servo Connector

For coordinated multiaxis moves, multiple servo-axis boards must be synchronized. The inter-servo connector carries the required synchronization signals.

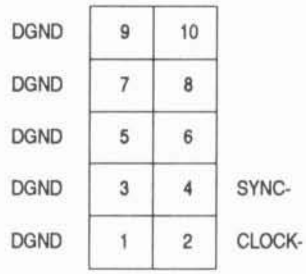


Figure 3-16e. Inter-Servo Pinout Diagram

CLOCK-

The CLOCK- line is driven by any HP 10936A named as a Master, (using *SVC, *CLK, and *MCM mnemonics) whether internal or external. All boards united in a master-slave relationship must be running off the same clock.

SYNC-

This line synchronizes multiple axes for coordinated multiaxis moves. SYNC- is driven by the board designated Master by the *SVC mnemonic. When slave boards see the SYNC- line go low they start their journey.

INTER-SERVO RIBBON CABLE

Servo-Axis boards can be interconnected to allow for coordinated multiaxis moves. The maximum number of boards that can be connected together is four in an HP 5507A, or six in an HP 5507B.

HP makes ribbon cables to interconnect Servo-Axis boards through their top inter-servo connectors. When the Servo-Axis boards are installed in the HP 5507A/B by HP, the appropriate cable is connected during system integration. If Servo-Axis boards are ordered as an add-on, the appropriate cable from those listed below should be used:

Two-board Interconnectiong Cable — HP Part Number 10936-60201
Three-board Interconnecting Cable — HP Part Number 10936-60202
Four-board Interconnecting Cable — HP Part Number 10936-60203
Five-board Interconnecting Cable — HP Part Number 10936-60204
Six-board Interconnecting Cable — HP Part Number 10936-60205

CAUTION

DO NOT program more than one master board for each Interconnect cable. Doing so will result in improper operation.

HP 10941A PROTOTYPING KIT

The HP 10941A Prototyping Kit consists of an extender board, a prototyping board and two interconnect cables. Approximately 219 square centimetres (34 square inches) of breadboard area (75% power-gridded) is available for adding custom circuitry to HP 5507A/B Laser Position Transducer Electronics. Additionally, up to 64 input and 64 output lines are supported by a factory loaded backplane interface circuit (customer must supply appropriate latches/buffers for all I/O lines used). This circuit and the PROM code may be copied for mass producing the added custom circuitry.

Power available is +5 V at 4.0 A (2 A fuse supplied), +15 V at 0.8 A and –15 V at 1.0 A. Multiaxis systems may reduce these values. To determine the overall power limitations, subtract your configuration's power requirements from the total power available to function boards and receivers (see HP 5507A/B specs in Section VIII). Also do not exceed the 82 watts (HP 5507A) or 122 watts (5507B) heat dissipation limitation.

An uncommitted 50-pin rear panel connector and an uncommitted internal axis inter-card connector (both HP 10932A Axis board style) may useful for linking added circuitry to external equipment and/or an adjacent function board.

The dimensions and component locator are shown in *Figure 3-17*. The schematic diagram is shown in *Figure 3-19*.

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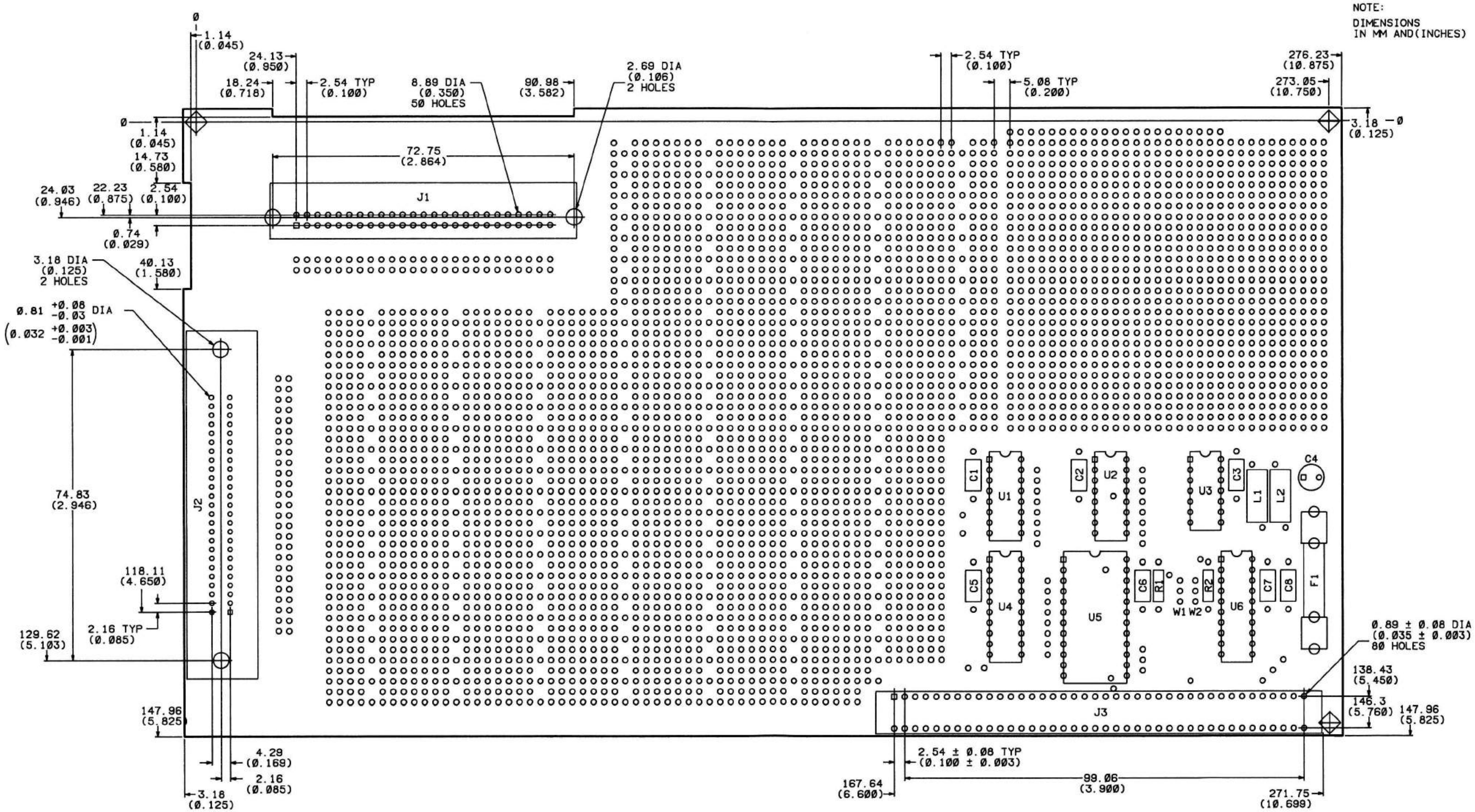


Figure 3-17. Prototyping Board Dimensions and Component Locator

Figure 3-17
PROTOTYPING BOARD DIMENSIONS AND COMPONENT LOCATOR

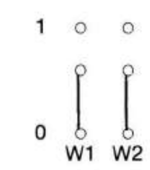
(See Page 3-19)

Hardware Overview

BACKPLANE INTERFACE

This circuitry connects user-added circuits to the HP-IB interface and performs all of the handshaking, and instruction and address decoding, required by the HP 5507A backplane.

The prototyping board may be configured to backplane address O, P, Q, or R (preset to O at the factory) by adjusting the position of two jumper blocks as shown in *Figure 3-18* below.



ADDRESS	JUMPER WIRES W1	W2
O	0	0
P	1	0
Q	0	1
R	1	1

Figure 3-18. Backplane Address Jumper Wires

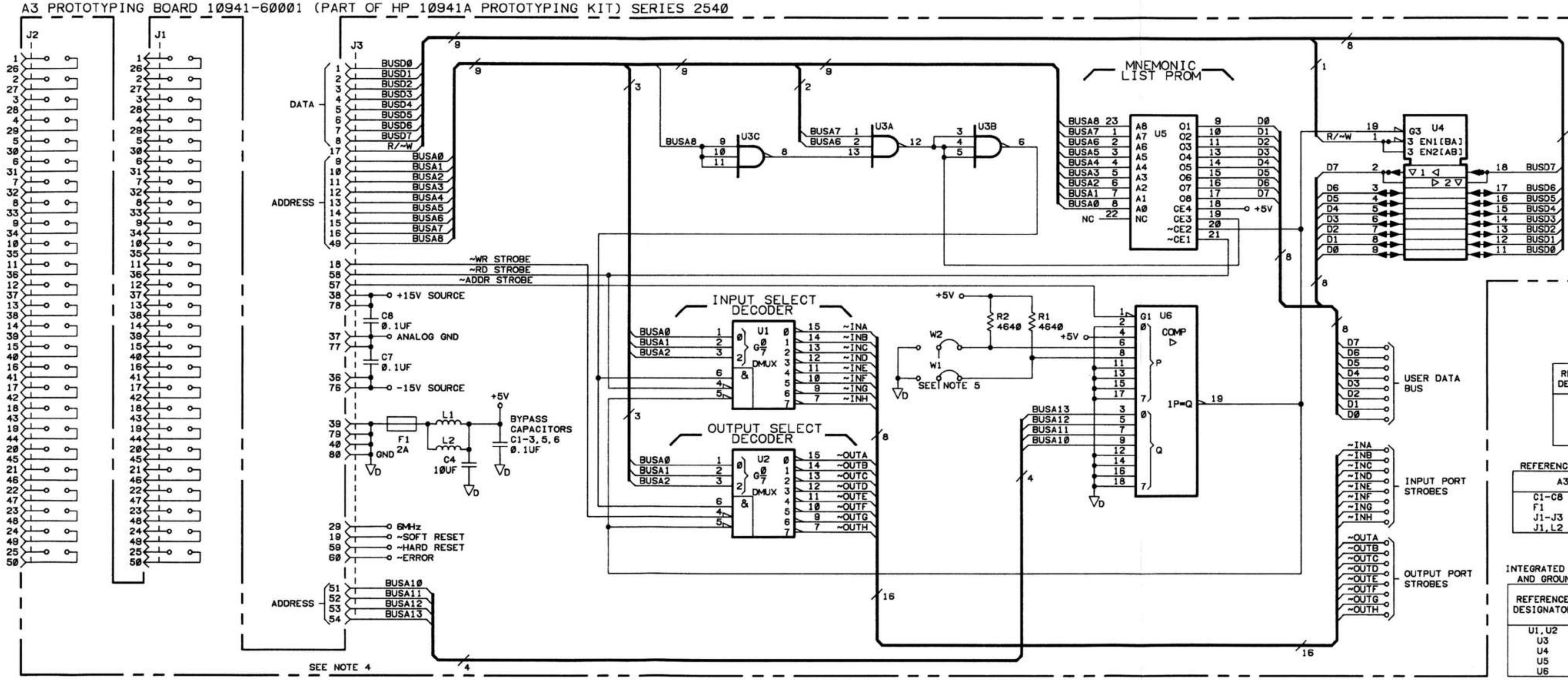
INPUT/OUTPUT LINES

The backplane interface on the prototyping board supplies eight negative true TTL compatible input strobes and eight similar output strobes. The strobes may be used with readily available, user supplied ICs to construct a customized I/O interface. See the "Reading Data" and "Writing Data" paragraphs of this section for detailed timing diagrams. The format for the data bus lines is:

8 BIT DATA FORMAT							
STROBE LINES: IN/OUT A– → H–							
D7	D6	D5	D4	D3	D2	D1	D0
MSB .... LSB							
0 TO 255 UNSIGNED BINARY (POSITIVE LOGIC)							

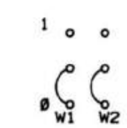
16 BIT DATA FORMAT															
STROBE LINES: IN/OUT A–, C–, E–, G–								IN/OUT B–, D–, F–, H–							
D7	D6	D5	D4	D3	D2	D1	D0	D7	D6	D5	D4	D3	D2	D1	D0
MSB .... LSB															
–32768 TO +32767 TWO'S COMPLEMENT BINARY (POSITIVE LOGIC)															

A3 PROTOTYPING BOARD 10941-60001 (PART OF HP 10941A PROTOTYPING KIT) SERIES 2540



NOTES

1. REFERENCE DESIGNATIONS WITHIN THIS ASSEMBLY ARE ABBREVIATED. ADD ASSEMBLY NUMBER TO ABBREVIATION FOR COMPLETE DESCRIPTION.
2. UNLESS OTHERWISE INDICATED:
   RESISTANCE IN OHMS;
   CAPACITANCE IN FARADS;
   INDUCTANCE IN HENRIES.
3. A TILDE ("~") PRECEDING A SIGNAL INDICATES A NEGATIVE-TRUE SIGNAL.
4. PINS 21-18, 30-35, 41-48, 50, 55, 56, 61-75 OF BACKPLANE CONNECTOR J3 HAVE NO CONNECTION.
5. JUMPER POSITIONS.



ADDRESS	JUMPER WIRE	
	W1	W2
O	0	0
P	1	0
Q	0	1
R	1	1

TABLE OF ACTIVE ELEMENTS

REFERENCE DESIGNATOR	HP PART NO.	MFG PART NO.
U1, U2	1820-2861	74F138
U3	1820-2867	74710
U4	1820-2075	74LS245
U5	10941-80001	82S141
U6	1816-3106	74ALS688

REFERENCE DESIGNATORS

A3 ASSY	
C1-C8 F1 J1-J3 J1, L2	R1, R2 U1-U6 W1, W2

MISCELLANEOUS PARTS

REFERENCE DESIGNATORS	HP PART NO.
C1-C3	0160-4557
C4	0180-2662
C5-C8	0160-4557
F1	2110-0002
J1	1251-8465
J2	1252-0558
J3	1251-7907
L1, L2	9100-1788
R1, R2	0698-3155
W1, W2	1258-0141

INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATOR	PIN NUMBERS	
	VCC	GND
U1, U2	16	8
U3	14	7
U4	20	10
U5	24	12
U6	20	10

Figure 3-19. Prototyping Kit Schematic Diagram

Figure 3-19
PROTOTYPING KIT SCHEMATIC DIAGRAM

(See Page 3-21)

AXIS INTER-CARD CONNECTOR

An uncommitted flat cable connector, located on top of the board, may be used to connect servo electronics or similar functions to adjacent boards such as an HP 10932A Axis Board or another HP 10941A Prototyping Kit. The two cables supplied with the prototyping kit mate with this connector. Compatible connectors are 3M 3425-6050 or equivalent.

REAR PANEL CONNECTOR

A 50-pin female connector, located on the rear panel, allows for any desired connections to external equipment. Example mating connectors are:

Amp: Champ® Connectors
3M: Delta Ribbon Connectors
T & B: Ansley® Ribbon Connectors

®Champ is a registered trademark of Amp
®Ansley is a registered trademark of T & B

FUSE PROTECTION

WARNING

FOR CONTINUED PROTECTION AGAINST FIRE HAZARD, REPLACE THE FUSE ON THE PROTOTYPING BOARD ONLY WITH A 250 VOLT FUSE OF THE PRESCRIBED RATING. DO NOT USE REPAIRED FUSES OR SHORT CIRCUITED FUSEHOLDERS.

The +5 Volt power line on the prototyping board is fused. Depending on the current requirements of the design, select a fuse with a value sufficient to give adequate protection against overloads (A 2 Ampere fuse is provided).

Data Transfers

READING DATA

Reading data from a mnemonic (see Section IV) causes the associated data strobe line(s) to pulse low. For example, sending the byte mnemonic PBYH? addresses the prototyping board set to address P and causes the INH– input strobe line to pulse low. This may be used to gate data onto the backplane bus using an 74LS244 octal buffer or equivalent. The strobe lines are low (active) for about 330 nanoseconds, and the data onto the bus must be stable 100 nanoseconds prior to the trailing edge of the strobe. The data may change any time after the trailing edge of the strobe. See the timing diagram in *Figure 3-20* below.

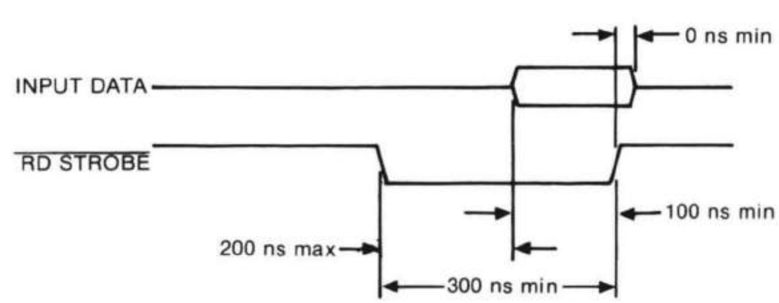


Figure 3-20. Timing Diagram for Reading 8-Bit Data

Word mnemonics are used to read 16-bit two's complement integers, high byte first. For example, sending PWDC? results in the INC– strobe line pulsing low, followed by the IND– strobe line. Together, these lines may be used to gate both bytes of the 16-bit integer value. See the timing diagrams in *Figure 3-21* below.

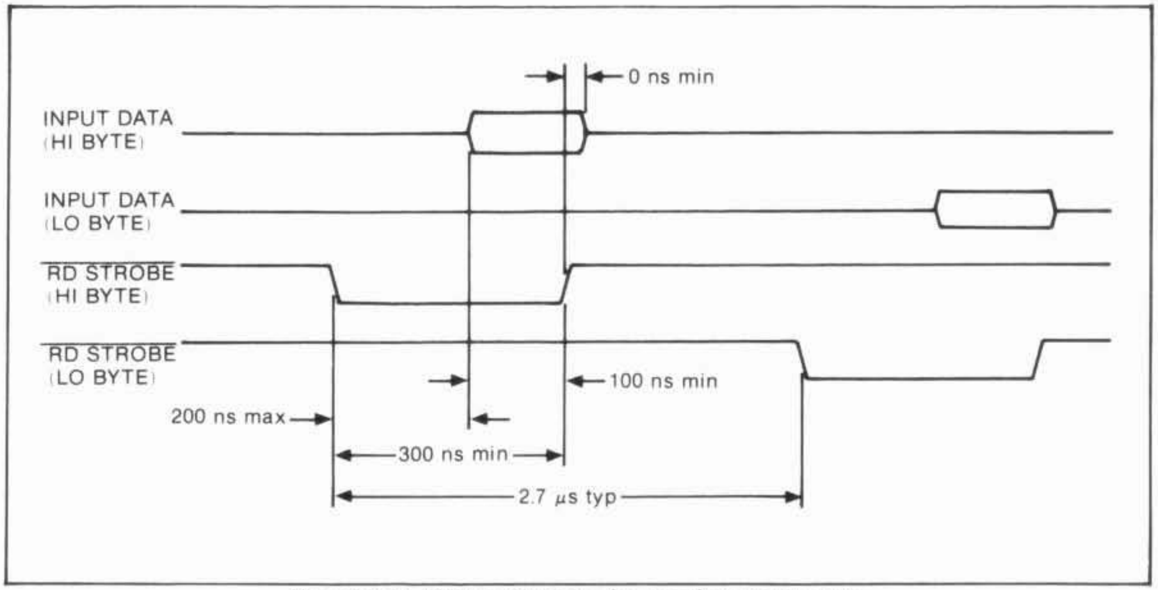


Figure 3-21. Timing Diagram for Reading 16-Bit Data

An on-board backplane buffer separates the prototyping board data bus from the HP 5507A internal data bus to prevent system errors due to possible malfunctions in any added circuitry.

WRITING DATA

Sending data to a prototyping board byte mnemonic (see Section IV) causes that data to appear on the prototyping board bus in unsigned 8-bit form and simultaneously causes the corresponding output strobe line to pulse low. This line may be used to clock an octal latch (74LS374, for example) to store the bus data for use by other customer electronics. The write strobe is about 200 nanoseconds long. Data on the bus is valid at least 60 nanoseconds prior to the trailing edge of the output strobe, and remains valid 35 nanoseconds after the trailing edge. See timing diagram in *Figure 3-22* below.

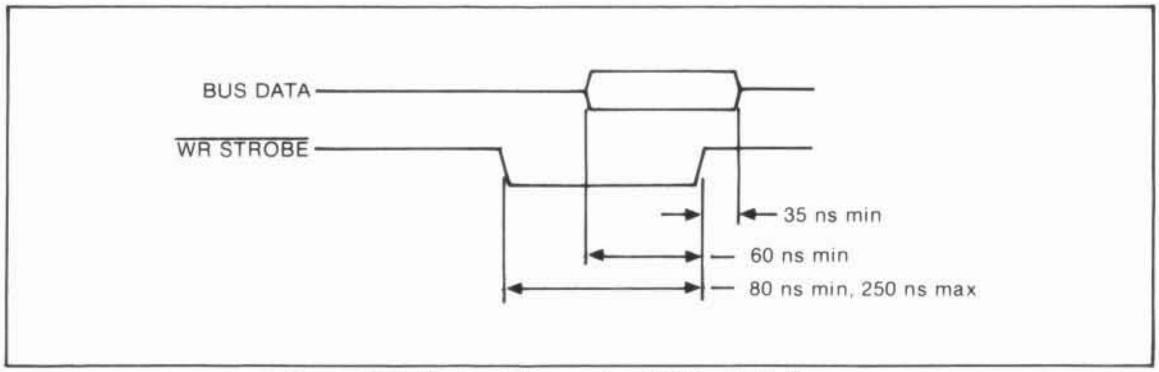


Figure 3-22. Timing Diagram for Writing 8-Bit Data

Sixteen-bit two's complement integers may be latched using an integer data item (word) mnemonic followed by an integer (e.g., PWDA 1026). The corresponding pair of data strobes sequentially pulse low with the high byte being written first. See the timing diagram in *Figure 3-23* below.

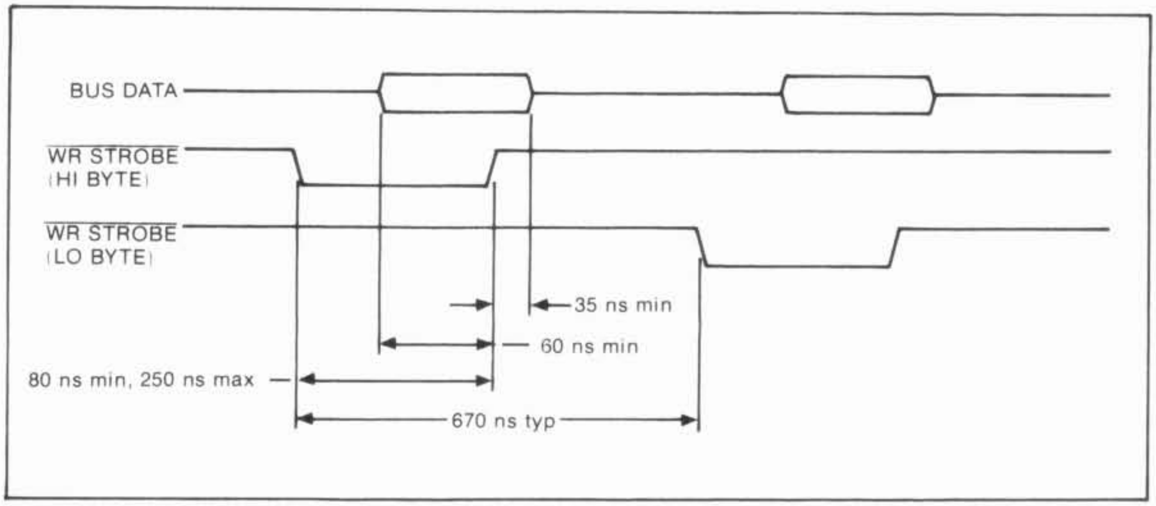


Figure 3-23. Timing Diagram for Writing 16-Bit Data

Using the Error, Reset, and Clock Lines

ERROR

This line is used to signal error conditions to the HP-IB interface (the front panel "SYSTEM ERROR" LED is on whenever this line is low). It may be used for this purpose or to signal onboard circuitry of system problems. The HP-IB interface may be programmed to assert SRQ when the Error line is low (true) to alert the system controller that an error has taken place. The Error line may be pulled low with a TTL open-collector driver such as a type 74LS05 IC. Once asserted low, it must be held low until a Soft Reset or Hard Reset signal occurs.

HARD RESET

This wire-OR, negative true TTL line functions as a power-up reset. It is asserted for 100 milliseconds minimum after the HP 5507A +5 volt power first comes up, and again for 2 milliseconds before power is lost at shutdown. In addition, the Hard Reset line may be asserted by the HP-IB BOOT command, to restart the HP 5507A in a manner identical to power turn on.

The Hard Reset line may be used to reset onboard circuitry or may be driven with a TTL open-collector gate such as the 74LS05. It must be pulled low for a minimum of 10 microseconds.

SOFT RESET

This wire-OR, negative true TTL level signal is used to reset errors such as programming and measurement errors. The line is brought low (for a minimum of 50 milliseconds) under the following conditions:

- The Laser Head locks after power-up
- The HP 5507A front panel reset switch is pressed
- An ERST command is received by the HP-IB Board
- An HP-IB device clear is received by the HP-IB Board

The Soft Reset line may be used in conjunction with the prototyping board as a driving line or a driven line. For example, it could be used to reset custom circuitry on the prototyping board (driving line). Or, as a driven line, the prototyping board could drive the soft reset line to clear HP 5507A errors. The Soft Reset line should be pulled low with a TTL open-collector gate, such as a type 74LS05 IC, for a minimum of 50 milliseconds.

6 MHz SYSTEM CLOCK

A 6.00 MHz ±1% TTL clock signal is available to drive one LSTTL load.

Error Messages

The prototyping board will not source any error messages. If a user-added gate is used to pull the backplane Error– line low, the HP-IB board responds with an "Error –500: Unidentified system error" indication when polled with the ERRM? data request.

Example I/O Configuration

NOTE

> The following example is a simple one to demonstrate the prototyping board's operation. More complex circuits can be added as described in Electronics Interface Examples in this Section.

Input and output ports may be added to the prototyping board as shown in *Figure 3-24*. An octal three-state buffer is used to gate user data onto the prototyping board data bus. Gating is controlled by an input port strobe signal (INA– through INH–). When this port is read, the data gated onto the prototyping board bus travels down the HP 5507A backplane to the HP-IB interface board. The HP-IB interface converts the eight bits of input information into a number between 0 and 255, which is sent out over the HP-IB interface.

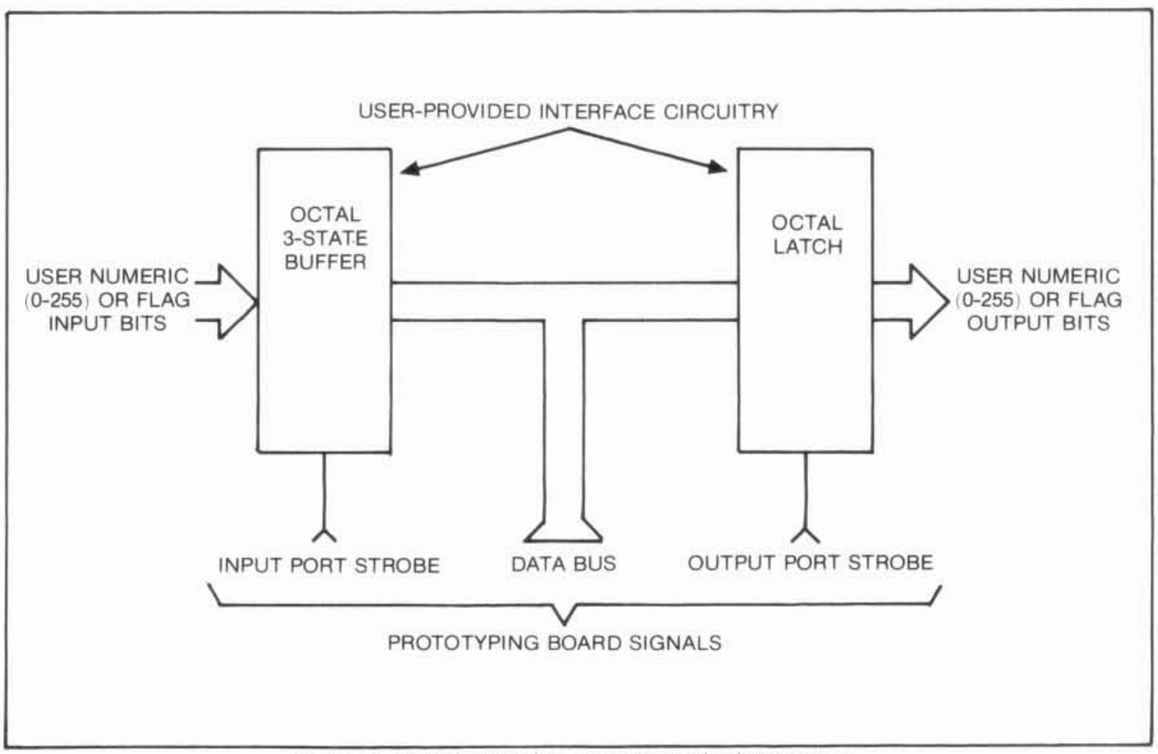


Figure 3-24. Input and Output Port Block Diagram

The following program lines (in HP Series 200 Basic) illustrate a "read" of input port 3 on a prototyping board set to address P.

```
10  OUTPUT 703;"PBYC?"
20  ENTER 703;Port_c_data
```

Output ports may be constructed with octal latches, as shown in the right side of *Figure 3-25*. The prototyping board data bus is sampled by the latch on the rising edge of an output port strobe signal (OUTA– through OUTH–). Data may be sent to output port C on a prototyping board set at address P in the following manner:

```
10  OUTPUT 703;"PBYC 206"
          OR
10  Port_c_data = 206
20  OUTPUT 703;"PBYC";Port_c_data
```

Sample implementations of eight-bit input and output ports are shown below. Sixteen bit I/O ports are similar in design, with a second buffer or latch gated by the next input or output strobe.

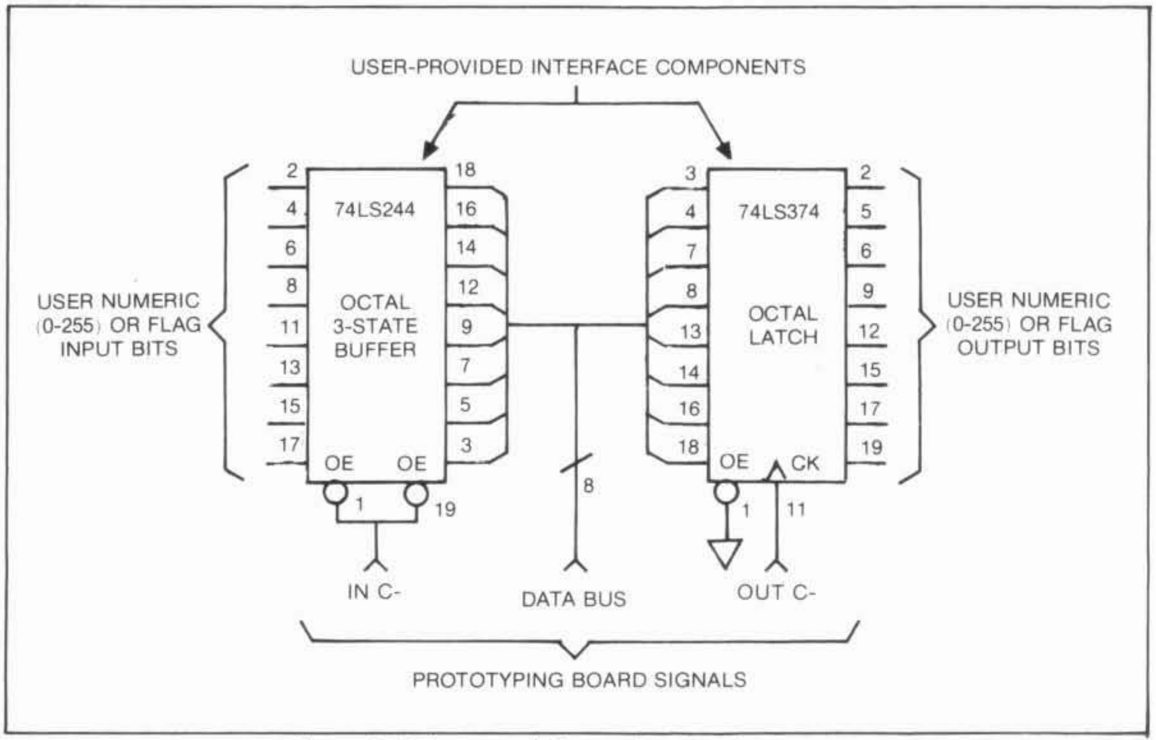


Figure 3-25. Input and Output Port Implementation

HP 10946B AUTOMATIC COMPENSATION BOARD

The HP 10946B Automatic Compensation Board provides either absolute or differential compensation numbers that can be used by the rest of the HP 5507A electronics. The wavelength-of-light data for the absolute compensation number is derived from air temperature, pressure and humidity sensors in the HP 10751A/B Air Sensor. The wavelength-of-light data for the differential compensation number is calculated from the measurement frequency of an HP 10780B Receiver monitoring the output of an HP 10717A Wavelength Tracker. In both cases, if an HP 10757A/B/C Material Temperature Sensor is connected to the HP 5507A, the material temperature signal is used with the wavelength-of-light data to generate the total compensation number. The source of the wavelength-of-light data, off-board air sensor or Wavelength Tracker, is controlled by software through your system controller. The HP 10946B board is shipped from the factory configured to read the HP 10751A/B Air Sensor and generate an absolute compensation number.

This board can be addressed over the backplane at addresses S, T, U, or V (preset to V at the factory). *Figure 3-26* shows how to set the compensation board address.

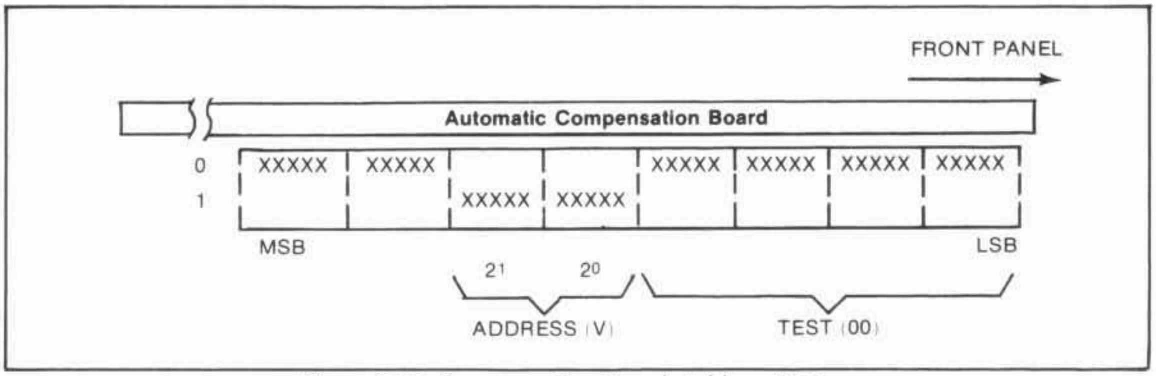


Figure 3-26. Compensation Board, Address Setting

Basic Operation

After running power-up self-tests, the Automatic Compensation board tests all sensor channels and enables those with a voltage between +1 and –1 Volts. The onboard microprocessor then reads the enabled channels through the Analog-to-Digital Converter and calculates a compensation number based on the values read, or the following default values:

Air Humidity: 50%

Air Temperature: 20°C

Air Pressure: 760 mm Hg

Material Temperature Average: 20°C

Thermal Coefficient of Expansion: 0

NOTE

There is a small warm up time required for the HP 10751A/B Air Sensor. Thus, the compensation number *CNV should not be used for about 5 minutes after power-up.

Calculating the compensation number (*CNV) from this sensor information takes about 100 milliseconds. However, the ADC takes 400 milliseconds to convert each channel and there could be up to six channels enabled. Thus it takes up to 2.4 seconds to generate a completely new compensation number. (Note that the number is recalculated after each ADC conversion.)

With the Wavelength Tracking function disabled (factory setting), the processor repeatedly calculates *CNV. However, if Wavelength Tracking is enabled (*WTE = 1), then, in addition to the above calculations, the processor also accumulates phase changes between an HP 10780B measurement signal and the laser head's reference signal. These phase changes correspond to changes in the wavelength of light (see paragraphs on HP 10717A in Section II). The accumulated phase is used to update the Wavelength Tracker Compensation number (*WTC). This computation takes about 10 milliseconds when no sensors are enabled and up to 100 ms when one or more sensors are enabled. The *WTC value includes material temperature compensation if the expansion coefficient has been programmed (see Section IV-K).

The Automatic Compensation board also has an alert function that is used to interrupt the system controller if the compensation number changes by more than a specified amount. The *WTE mnemonic selects which compensation number, *CNV or *WTC, is used to generate this alert.

When more than simple compensation is required, additional mnemonics selectively enable and disable sensor channels and the Wavelength Tracking function.

Rear Panel Connectors

The Automatic Compensation board is connected to the HP 5507A rear panel via a 12-conductor flat ribbon cable, which is routed to the compensation connector board that supports connectors 1 through 6 (*Figure 3-27*), and a 4-conductor cable that connects the Automatic Compensation board directly to rear panel connector 7 (*Figure 3-27*).

CABLES

HP 10790A/B/C Receiver Cable

The HP 10790A/B/C Receiver Cable transmits the measurement signal from the HP 10780A Receiver to the HP 5507A. The A model is 5 metres (16 feet) in length, the B model is 10 metres (33 feet), and the C model is 20 metres (64 feet).

HP 10793A/B/C Laser Head Cable

The HP 10793A/B/C Laser Head Cable is used to connect the HP 5517A or HP 5518A Laser Head to the HP 5507A. The A model is 3 metres (10 feet) in length, the B model is 7 metres (23 feet), and the C model is 20 metres (64 feet).

HP-IB Cables

An HP-IB Interface Cable is required to interface from a controller to the HP 5507A. Various lengths of HP-IB cables are available from HP (HP 10833 A/B/C/D).

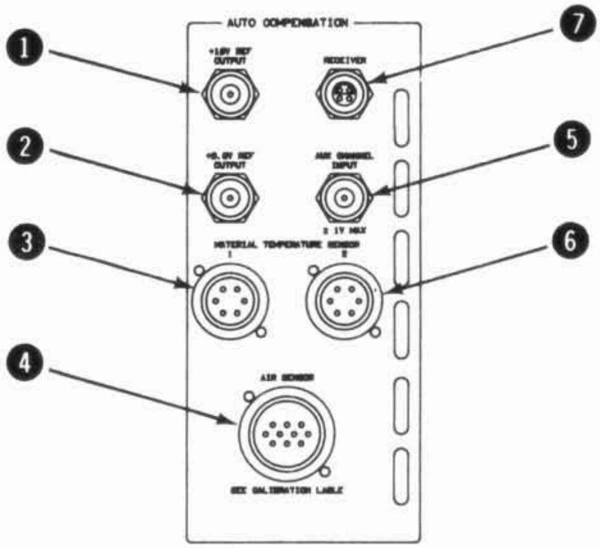
Servo System Cabling

The HP 5507A connects to a servo system through one or more of its rear panel 50-pin female connectors. The axis board and the prototyping board have identical connectors which mate with the following connector types:

Amp: Champ® Connectors
3M: Delta Ribbon Connectors
T & B: Ansley® Ribbon Connectors

®Champ is a registered trademark of Amp
®Ansley is a registered trademark of T & B

Any of the 50-pin male versions of the above connectors are suitable for use. Timing and drive constraints limit the cable length to 3 metres for the axis board outputs (see "Axis Board" section for pinouts). The maximum length of cables connected to the prototyping board will depend on the added custom circuitry.



+10 VOLT REFERENCE BNC — CONNECTOR 1

The 10 Volt reference value can be monitored at any time through this BNC connector. It is also used during calibration.

+0.5 VOLT REFERENCE BNC — CONNECTOR 2

The +0.5 Volt reference value can also be monitored at any time through this BNC connector. It is also used during calibration.

MATERIAL TEMPERATURE SENSOR — CONNECTOR 3 & 6

These two 6-pin circular connectors accept the 10757A/B/C Material Temperature Sensors (connector 3 corresponds to *MT1).

AIR SENSOR — CONNECTOR 4

This 10-pin circular connector accepts the 10751A/B Air Sensor.

AUX CHANNEL INPUT BNC — CONNECTOR 5

This BNC input connector provides a direct path to one channel of the 12-bit ADC on the compensation board. A dc voltage (range ±1 Volt) can be put on this line and the ADC conversion read through HP-IB. Production test uses this input to verify the ADC linearity and accuracy. In addition to testing, it can also be used for custom sensors.

RECEIVER — CONNECTOR 7

This connector is used for the Wavelength Tracker axis receiver input. It provides the dedicated receiver with +15 Volts and accepts the measurement signal (100 kHz to 5.0 MHz) from the receiver.

Figure 3-27. Location of Rear Panel Connectors

ELECTRONICS INTERFACE EXAMPLES

Analog Servo Controller

Figure 3-28 illustrates how a simple analog servo controller may be implemented on a prototyping board using signals available on the HP 10932A Axis Board's inter-card connector.

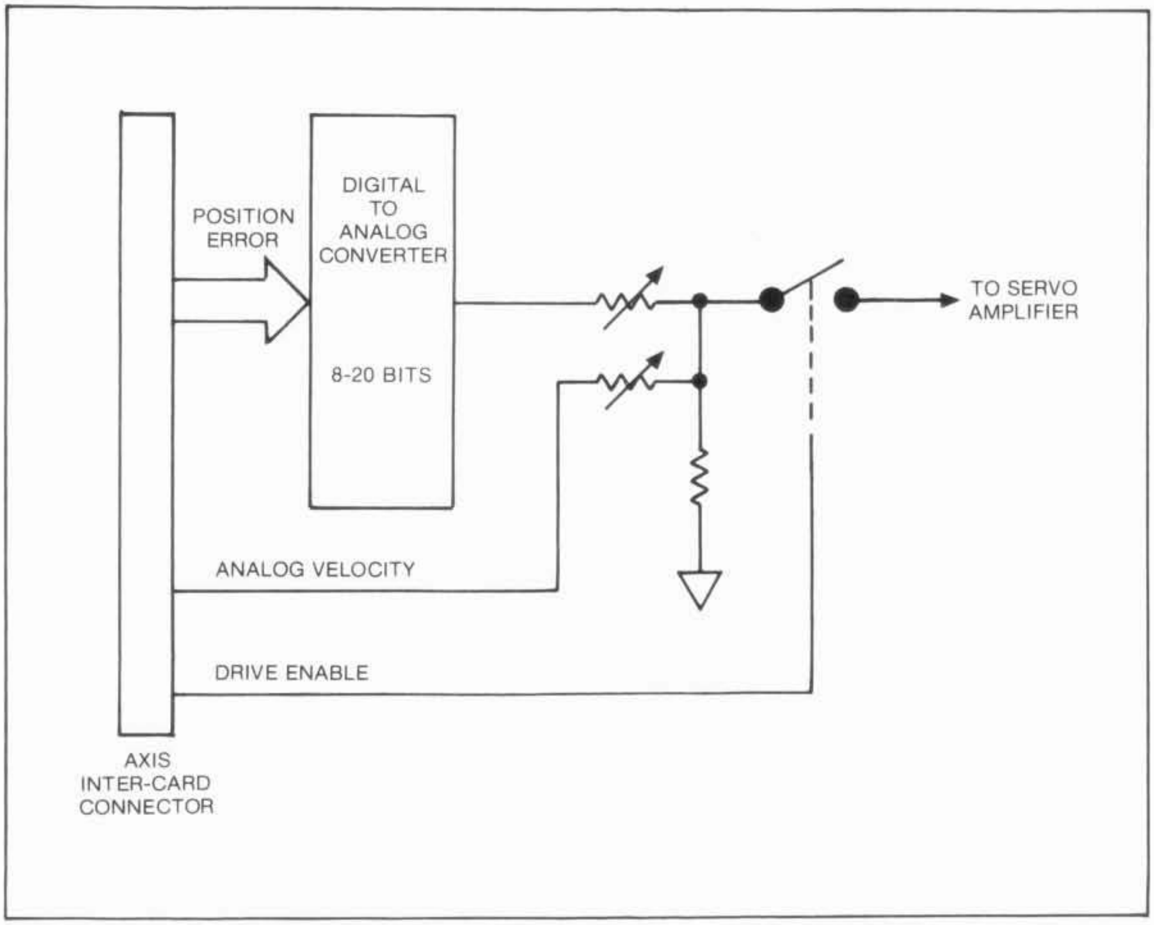


Figure 3-28. Analog Servo Controller Block Diagram

The controller is a proportional-plus-derivative type, with velocity feedback coming from the HP 10932A Axis Board's Analog Velocity signal. The Position Error signals provided by the HP 10932A Axis Board are converted to an analog error voltage by a digital-to-analog converter, and mixed with the velocity feedback signal. The HP 10932A Axis Board Drive Enable Out– line is used to gate the servo motor drive off should a measurement error occur.

The HP 10932A Axis Board is programmed using *CLP to set the error clipping level at the number of bits necessary to pin the DAC at full scale when the position error is large. In normal operation, the servo loop operates as follows:

- When a new destination is sent to the HP 10932A Axis Board, the Position Error outputs jump to indicate the difference between actual and desired positions.
- The DAC output also jumps, and may go to full scale if the position error is large enough to clip at the level set by the *CLP factor.
- The stage then begins to accelerate toward the destination.

- The slewing speed toward the destination is determined by the amount of velocity feedback applied: normally, the velocity feedback gain is adjusted to balance out the full scale DAC output at maximum desired stage velocity.
- While the DAC output is clipped, the loop behaves as a velocity loop rather than a position feedback loop, and moves toward the destination at a controlled speed.
- As the stage nears its final destination, the DAC output is reduced from full scale, and the loop again operates in the position feedback mode.

The number of bits needed in the DAC varies with the application as it determines distance D in *Figure 3-29*. If this distance is too short, excessive overshoot or oscillation may occur as the loop comes out of slewing too late to stop at the destination. Thus the required loop "stiffness" will determine the size of the DAC.

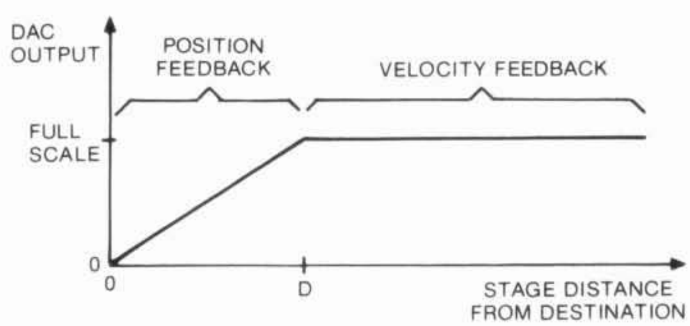


Figure 3-29. Servo Loop Feedback Profile

Digital Servo Controller

High performance servo applications may require the use of a digitally controlled servo loop. The HP 5507A internal structure is well organized for this type of position control. *Figure 3-30* illustrates the functional blocks needed to implement such a loop using the HP 10932A Axis Board and the HP 10941A Prototyping Board.

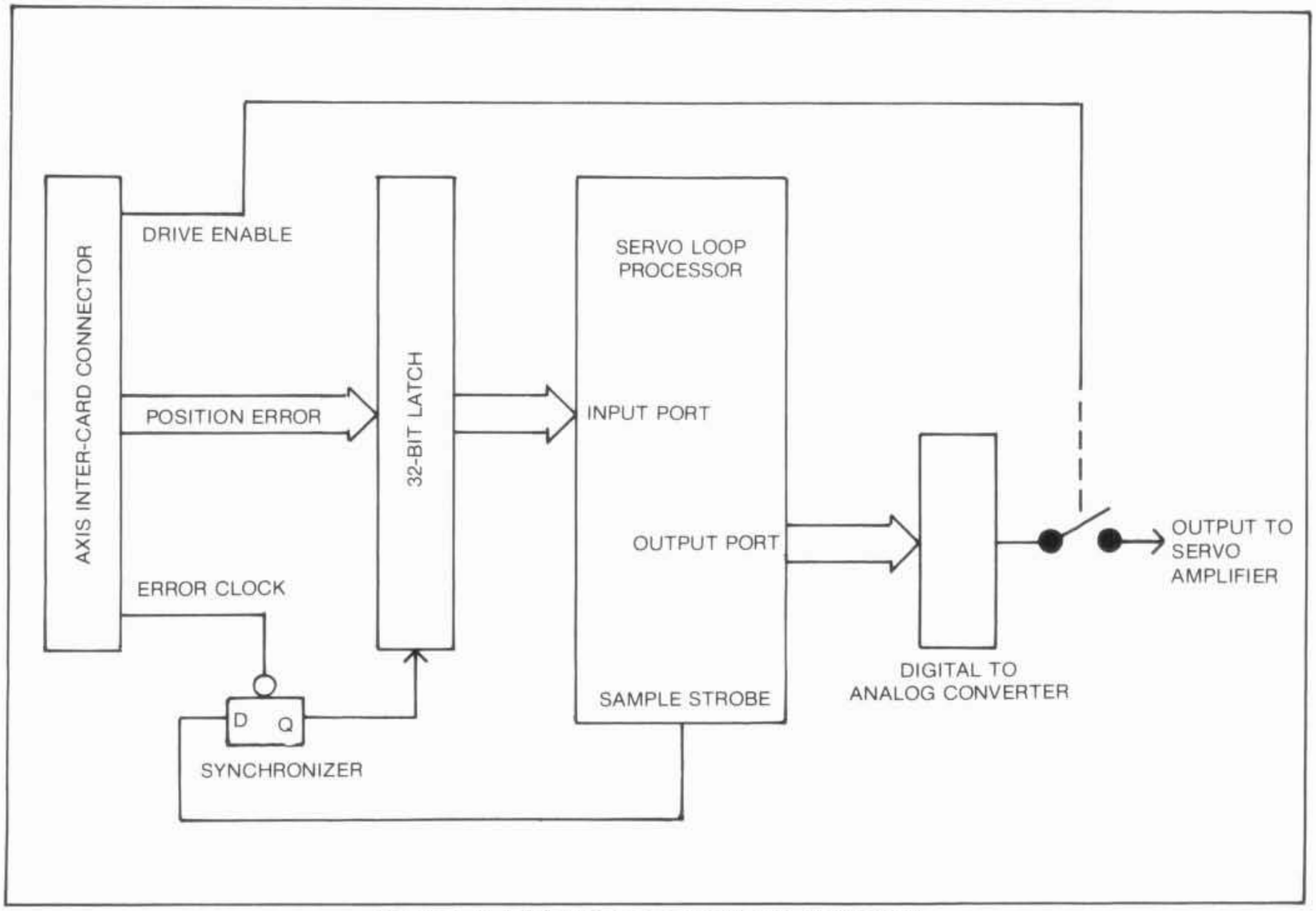


Figure 3-30. Digital Servo Controller Block Diagram

Position Error signals from the axis inter-board connector are fed into a latch, so they may be frozen at a rate suitable for microprocessor sampling. The Position Error outputs change on positive transitions of the Error Clock. This signal is used to synchronize the servo controller-generated sampling strobe for Position Error sampling. The HP 10932A Axis Board's Drive Enable line may be used to gate off the position feedback should a measurement error occur.

The servo loop processor executes the control algorithm required for loop stability. A digital servo processor allows excellent trajectory control, along with advantages gained from variable servo loop compensation and automatic tuning.

Loop parameters and/or a control program can be downloaded through HP-IB and the Prototyping Board's I/O interface.

SECTION IV
SOFTWARE CONTROL OF THE HP 5527A LASER POSITION TRANSDUCER

SECTION IV

SUBSECTION A
INTRODUCTION

CONTENTS

SECTION IV
SOFTWARE CONTROL OF THE
HP 5527A /B LASER POSITION TRANSDUCER

INTRODUCTION

This section provides information to program and operate your system. The first subsection is general and applies to all instrument programming. The remaining subsections contain HP 5507A/B specific information. Most is reference material, but each board subsection contains useful examples. Section IV is subdivided as follows:

- *SUBSECTION A, INTRODUCTION.* Covers section organization, programming objectives and methods, and a system level overview. The programming information provides a guide and specifies what is needed to program the HP 5507A/B. The system-level overview presents a brief overview of the HP 5507A/B, its function boards and their addresses.
- *SUBSECTION B, HP 5507A/B HP-IB INTERFACE.* Explains HP-IB addresses, IEEE standards, syntax, number formats, ranges, and interrupts. Also covers the HP-IB board's mnemonics, reset response, error indicators, and messages.
- *SUBSECTION D, HP 10932A/B AXIS BOARD.* Covers set-up, operation and miscellaneous mnemonics. Explains reset response, external sampling, deadpath compensation, and error messages.
- *SUBSECTION E, HP 10934A A-QUAD-B AXIS BOARD.* Covers set-up, operation and miscellaneous mnemonics. Explains reset response, external sampling, serial and parallel operation, geometric correction, error recovery, and error messages.
- *SUBSECTION F, HP 10936A/B SERVO-AXIS BOARD.* Covers set-up, operation and miscellaneous mnemonics. Also explains reset response, binary interface operation, buffer utilization, servo system tuning, custom difference equations, and error messages.
- *SUBSECTION I, HP 10941A PROTOTYPING BOARD.* Discusses data formats, reading and writing data, error messages, and mnemonics.
- *SUBSECTION K, HP 10946B/C AUTOMATIC COMPENSATION BOARD* (used with the HP 10751A/B Air Sensor, HP 10757A/B/C Material Temperature Sensor, and/or HP 10717A Wavelength Tracker). Discusses operation and presents the mnemonics, reset response and error messages for the HP 10946B/C Automatic Compensation board.
- *SUBSECTION M, HP-IB OPERATION WITH THE HP9000 SERIES 200 COMPUTER.* Explains software control and programming using the HP 9000 Series 200 Computer and HP Basic 3.0.
- The Appendices include information to both augment and summarize information found in this section. They are:
- *Appendix A,* Mnemonic Table-Summary (Alphabetized)
- *Appendix B,* Error Messages in Numerical Order
- *Appendix C,* Syntax Diagrams and Numeric Representation Examples
- *Appendix D,* HP-IB Basics

PROGRAMMING OBJECTIVES AND METHODS

The objective of programming is to obtain the defined results from the system under control. The methods of programming are dependent on the requirements of the system controller and the capabilities of the sytem under control. Therefore, in order to effectively program the Laser Position Transducer, you must understand and be able to use the following information:

a. LANGUAGE OF THE SYSTEM CONTROLLER. The operating and control manuals supplied with the controller contain descriptions of the commands and syntax used with its paticular control language. The controller documentation should include:

- Information about how to generate the HP-IB Bus Commands and Instrument Function Codes (mnemonics) required by the Laser Position Trnasducer.
- Information about how to create (and save) programs (sequences of individual instruction that can be used to control the Laser Position Transducer.

b. OPERATION OF THE LASER POSITION TRANSDUCER. Prior to programming the Laser Position Transducer, you should be familiar with the information in Sections I, II, and III that applies to the configuration of the system being programmed.

c. LANGUAGE OF THE HP5507A/B. Finally, you should be familiar with the addresses and commands that make up the instructions applicable to the units in your system.

The remainder of this section covers item c above. Read it, and study the commented programs before programming your system.

SYSTEM LEVEL OVERVIEW

The HP5507A/B Laser Position Transducer Electronics is used in conjunction with an HP laser head (HP 5517A/B/C or HP 5518A) and HP optics. The system serves as the position feedback element in both closed-loop servo control systems and open-loop precision measuring systems.

The HP 5507A/B may contain the following function boards:

HP-IB board (1 per system)	Full HP-IB interface to the host computer.
Axis board (≤6 per system)	Keeps track of position and generates position error outputs for custom servo control loops.
A-Quad-B Axis board (≤6 per system)	Keeps track of position and generates A-quad-B or U/Down pulses corresponding to position changes. Also provides two serial interfaces and an 8-bit parallel interface to the host computer(s).
Servo-Axis board (≤6 per system)	Keeps track of position, generates reference positions for profiled motion and ocmbines the two to generate motor drive signals. Also provides a binary interface to the host computer.
Automatic Compensation Board (≤1 per system)	Automatic compensation for air and material temperature effects on the measurement.
Prototyping Board (≤4 per system)	Provides breadboarding capability for user-designed circuits.

The HP 5507A/B automatically configures itself for the installed function boards. Each HP 5507A/B board (except the HP-IB board) must be assigned a unique backplane address. *Table 4A-1* lists all possible addresses and the associated function boards.

Table 4A-1. Possible Function Board Addresses

Mnemonic Prefix†	Function Board Assignment
K	Reserved for future use
I	Reserved for future use
M	Reserved for future use
N	Reserved for future use
O††	Prototyping board
P	Prototyping board
Q	Prototyping board
R	Prototyping board
S	Compensation, Axis, or Servo-Axis board
T	Compensation, Axis, or Servo-Axis board
U	Compensation, Axis, or Servo-Axis board
V††	Compensation, Axis, or Servo-Axis board
W(4)	Axis or Servo-Axis board
X(1)	Axis or Servo-Axis board
Y(2)	Axis or Servo-Axis board
Z(3)	Axis or Servo-Axis board

† Throughout the manual an asterisk (*) will be used to represent this prefix for general case mnemonics.

†† Factory switch setting for Prototyping or Compensation boards.

(1) Axis or Servo-Axis board switch setting of both a single-axis system and the X-axis board of a multiaxis HP 5507A.

(2) Switch setting of the second axis or Servo-Axis board installed in a multiaxis system.

(3) Switch setting of the third axis or Servo-Axis board installed in a multiaxis system.

(4) Switch setting of the fourth axis or Servo-Axis board installed in a multiaxis system.

There are more addresses available, 16, than physical board slots, 8. Board position on the backplane bus has no bearing on address assignment. However, all factory integrated systems will have consistent board positions and addresses.

SECTION IV

SUBSECTION B
HP 5507A HP-IB INTERFACE

CONTENTS

SECTION IV

SUBSECTION B
HP 5507A HP-IB INTERFACE

HP 5507A HP-IB INTERFACE

The HP-IB Interface Board is the primary channel for low speed data and control transmission between the function boards and an external controller. The interface is designed to meet IEEE-488, IEEE-728, and IEEE-P754 standards for general purpose instrument programming.

Summary of HP-IB Standards

IEEE-488 STANDARDS

The HP-IB board furnishes the following IEEE-488 interface functions: (Refer to Section III for a description of these functions)

SH1	Source Handshake capability
AH1	Acceptor Handshake capability
T2	Talker, Serial Poll, no Talk Only
TE0	No Extended Address Talker
L2	Listener, no Listen Only
LE0	No Extended Address Listener
SR1	Serial Poll capability
RL0	No Remote-Local capability
PP0	No Parallel Poll capability
DC1	Device Clear, Selected Device Clear
DT1	Device Trigger capability
C0	No Controller capability

IEEE-728 STANDARDS

The HP 5507A is compatible with the following IEEE-728 standards.

Program Message Header Type: HR3
Numeric Input Format: NR1, NR2, NR3, BDFA, BDFD
Numeric Output Format: NR1, NR2, BDFA, BDFD

IEEE-P754 STANDARDS

All block data formats use eight IEEE-P754 floating point data bytes (double precision).

Data Message Transmission Capabilities

The information contained within the body of each message transmitted and received by the HP 5507A is represented in either the numeric or the block data format. *Table 4B-2* lists and describes the IEEE Format Codes that apply to the HP 5507A as defined by the IEEE-728 standard. The HP 5507A will accept data in the NR1, NR2, or NR3 Input Data Format without being programmed to do so. At power-up, numeric data is output in either the NR1 or NR2 format, depending on the data type. The HP 5507A must be programmed to transmit floating point data messages in the BDFA and BDFD Block Data Formats, but will accept such data (for integer or floating point variables) without being programmed to do so. Also, the HP 5507A can be programmed to output floating point data in a block format that is compatible with the HP Series 200 Computers.

For detailed syntactic diagrams and examples for each applicable data format type, refer to the numeric input and output paragraphs along with Appendix C.

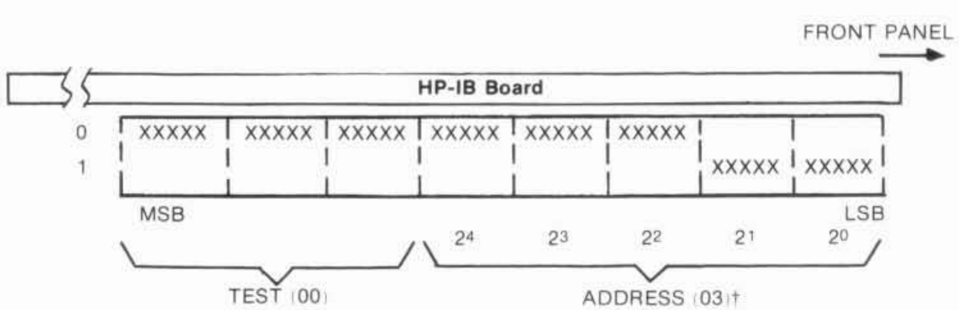
Table 4B-2. HP 5507A IEEE-728 Standard Capabilities

IEEE Format Code	Numeric Input/Output Data Format	Description
NR1	IEEE-728 Implicit Point Input/ Output Data Format	Consists of a set of implicit point representations of numeric values, that is, the decimal point is implicitly considered to be placed (but not transmitted) at the end of the string of digits.
NR2	IEEE-728 Fixed Point Input/ Output Data Format	Consists of a set of explicit point representations of numeric values with the decimal indicated by a decimal point. For clarity, the decimal point should be preceded by at least one digit.
NR3	IEEE-728 Scaled Point (Floating Point) Input Data Format	Consists of a set of scaled representations with either implicit or explicit decimal point together with an exponent notation.
BDFA	IEEE-728 Binary Block A Input/Output Data Format	Used in applications requiring higher speeds. Transmits data in eight data byte blocks.†
BDFD	IEEE-728 Block D Input/Output Data Format	Used in applications requiring higher speeds. Transmits data in eight data byte blocks.†

†Data is transmitted as eight IEEE-P754 Floating Point Data Bytes (Double Precision).

HP-IB Address Capabilities

The HP-IB address is factory-set to 03, and may be changed through a dip switch on the top edge of the HP-IB board. The address may be set from 0 through 30 by setting the desired address in binary. The least significant address bit is located at the end of the switch closest to the front of the instrument. The most significant bit is the fifth switch from the front panel. Logical "ones" are indicated when the switch levers point away from the board while zeros are toward the board. The three highest switch bits are used during service, and must be set to zero for normal operation.



† The HP-IB board's address may be set from 0 to 30 by setting the desired binary address on this switch.

Figure 4B-1. HP-IB Address Switch

The following table shows ASCII characters and corresponding codes of the Listen Address Group and Talk Address Group commands.

Table 4B-3. HP-IB Addresses

Address Characters		Address Code	Address Switch Settings				
Listen	**Talk**	**Decimal**	2^4	2^3	2^2	2^1	2^0
Space	@	0	0	0	0	0	0
!	A	1	0	0	0	0	1
"	B	2	0	0	0	1	0
#	C	3	0	0	0	1	1
$	D	4	0	0	1	0	0
%	E	5	0	0	1	0	1
&	F	6	0	0	1	1	0
'	G	7	0	0	1	1	1
(	H	8	0	1	0	0	0
)	I	9	0	1	0	0	1
*	J	10	0	1	0	1	0
+	K	11	0	1	0	1	1
,	L	12	0	1	1	0	0
-	M	13	0	1	1	0	1
.	N	14	0	1	1	1	0
/	O	15	0	1	1	1	1
0	P	16	1	0	0	0	0
1	Q	17	1	0	0	0	1
2	R	18	1	0	0	1	0
3	S	19	1	0	0	1	1
4	T	20	1	0	1	0	0
5	U	21	1	0	1	0	1
6	V	22	1	0	1	1	0
7	W	23	1	0	1	1	1
8	X	24	1	1	0	0	0
9	Y	25	1	1	0	1	0
:	Z	26	1	1	0	1	0
;	[	27	1	1	0	1	1
<	\	28	1	1	1	0	0
=	]	29	1	1	1	0	1
>	^	30	1	1	1	1	0
?	_	31††	1	1	1	1	1

††Unlisten and Untalk Commands. Do not set to this address.

HP-IB Programming Basics

HP-IB BUS CONTROL

In most cases, a language system's drivers for the IEEE-488 interface will automatically manage the bus. But occasionally, it is necessary to manage the HP-IB Bus by sending explicit sequences of bus messages. These bus messages are used to specify what device will transmit and what devices will receive the transmitted data string. For example, the following sequence of commands and data must be transmitted to send a data string from the controller to the HP 5507A:

- To differentiate between data and commands, the ATN line is asserted (set true) by the HP-IB bus controller.
- The UNL interface message byte is sent to unaddress all current listeners on the bus. The ASCII unlisten command is "?".
- The talk address is specified by sending the talker's ASCII address character. In this case the talker address is that of the controller. The address character sent over the bus is "U": corresponding to a bus address of 21 (default for HP computers).

- The listen address is specified by sending the listener's ASCII address character byte. The listen address is that of the HP 5507A's HP-IB board. The listen address character sent over the bus is "#": corresponding to a bus address of 03 (see *Table 4B-3*).
- The ATN line is set false to tell the devices that the bytes that follow are data (instead of commands).
- The data string variable is transmitted one character at a time.
- Most bus transmissions are terminated with a Carriage Return (CR) and Line Feed (LF) byte. The End or Identify (EOI) bit may also be asserted but is dependent on the type of controller used.

See Appendix D for a more complete discussion of the HP-IB Bus.

HP 5507A PROGRAMMING BASICS

The HP-IB Board accepts command or data mnemonics, accompanied by numeric data, and channels the data or commands to the appropriate HP 5507A function board. Command and data identifiers take the form of four-character mnemonics sent in standard ASCII representation. All space characters in HP-IB programming messages are ignored, and lower case characters are internally converted to upper case (except when block data input format is being used).

All data mnemonics must be followed by either a numeric argument (when sending data), or a question mark "?" (when asking for data). An error will result if either of these is not present. Unlike data items, command mnemonics do not take or return a numeric argument.

General Program Line Format

Figure 4B-2 shows the general format for generating HP 5507A programs. The format is, to some degree, dependent on the controller used with the system. Each program statement should include the following:

Keyword	A group of characters that is understood by the controller's language system to represent some predefined action. Keywords are capable of executing the HP-IB bus messages, allowing devices on the bus to exchange control and measurement information.
Interface Select Code	Selects which I/O interface the keyword will act on. (In some controllers, this may be part of the keyword itself). For HP Series 200 Computers, the HP-IB interface select code is 7.
Primary Address	Contains the talk or listen address of the device involved. The HP 5507A's primary address is preset to 03 at the factory.
Item Separator	Use of item separator's (i.e., "," and ";") are dependent on the controller and its control language.
String and Numeric Variables	The string variable will contain the HP 5507A system program information, command or data mnemonics. The numeric data can either be within the string variable or in a separate numeric variable.

Examples of String and Numeric Variables:

1) A$;N — where A$ = "XDES"
N = 1.23

2) A$;N;B$;M — where A$ = "XDES"
B$ = ";IMSK"
N = 1.23
M = 128

3) A$;N1;";";N2;";";N3 — where A$ = "XDES"
N1 = 1.0
N2 = 2.0
N3 = 3.0

(The quoted semicolons are item separators required by the HP 5507A. The other semicolons may be required by the computer's language system).

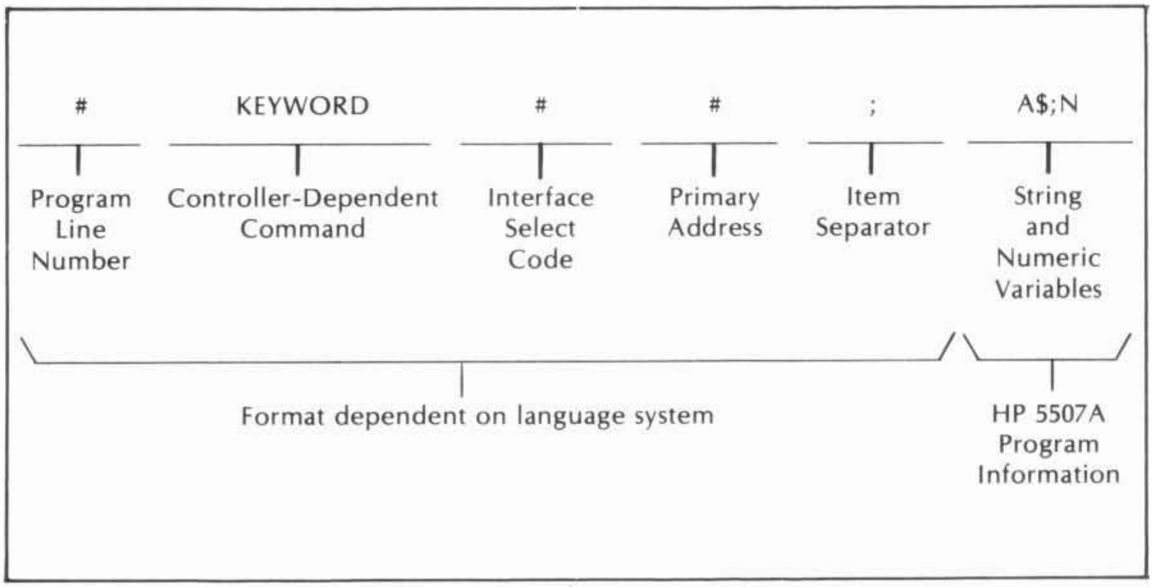


Figure 4B-2. General Programming Format

The format used for transmitting information (string and numeric variables) from the controller to the HP-IB board follows IEEE-728 standards.

I/O Termination Sequences

The HP-IB board recognizes the following as ASCII programming string terminators when input:

- Linefeed Byte (LF)
- Data byte with End or Identify Bit asserted (DAB with EOI)
- Linefeed byte with End or Identify Bit asserted (LF with EOI)

When using block data input formats, only the DAB with EOI terminator is accepted.

The HP-IB Board's output ASCII terminators are as follows:

Output Format	Format Description	ASCII Terminator
0††	Basic ASCII output	CR, LF with EOI
1	†BDFA	EOI Asserted with last data byte.
2	†BDFD	EOI asserted with last data byte.
3	†Series 200 Block Data	None sent. Controller must terminate transfer after eight bytes have been received.

†Applies to floating point data only.
††Integer and ASCII data always output in format 0.

Additional Characteristics

Other programming considerations are :

- Carriage returns preceding linefeeds are ignored.
- The entire programming string must be received from the HP-IB Bus before processing can begin on that string. New strings are not accepted until processing of the previous string is complete.
- Processing errors in the middle of the string aborts the processing of the remainder of the string.

Note

The following paragraphs contain programming examples using an HP Series 200 Computer running Basic 3.0. Using other controllers or language systems will alter the syntax (see controller documentation), but the HP 5507A programming strings remain the same.

SENDING COMMANDS TO THE HP 5507A

Commands are the simplest information to send to the HP 5507A. The controller must send the talk and listen address (usually automatic) followed by the string constant. The method by which the controller sends the address command is controller-dependent while the string constant is programming information that is instrument-dependent. The example that follows sends the ERST (Error Reset) command.

```
OUTPUT 703;"ERST"
```

- String Constant: ERST Mnemonic
- Primary Address: HP-IB device address (factory set at 03)
- Controller-dependent "keyword" and interface select code that instructs the controller to send the information that follows the item separator ";" to the device at the specified HP-IB primary address.

When the OUTPUT 703 statement is used to send data to the HP-IB controlled HP 5507A, the following sequence of commands and data are sent through the bus.

NOTE

> Items 1 through 5 are automatically executed by the HP-IB drivers when the primary talk or listen address is specified.

1. The ATN line is set true to tell all HP-IB devices that the following bytes are commands. (Conversely, when the ATN line is false, the devices on the bus will interpret the bytes as data).
2. The unlisten command is sent ("?").
3. The talker's address command is sent ("U"). In the above example, the system controller is the talker. The ASCII address command ("U") corresponds to the HP-IB bus address of 21.
4. The listener's address command is sent ("#"). The ASCII listen command corresponds to the device primary address of 03.
5. The ATN line is set false to tell the devices on the HP-IB bus that the bytes are data (instead of commands).
6. The data bytes "E", "R", "S", "T", CR, and LF are sent. All data bytes are sent using the HP-IB interlocking handshake to ensure that the listener (HP-IB Board) has received each byte.

Several commands can be sent in a single string. These multiple commands will execute sequentially, however semicolons must separate them within the string.

```
OUTPUT 703;"ERST;XMET;FMT0"
```

- String Constant composed of three commands executed sequentially from left to right.
- Primary Address: HP-IB device address (factory set at 03)
- Controller-dependent "keyword" and interface select code that instructs the controller to send the information that follows the item separator ";" to the device at the specified HP-IB primary address.

WRITING DATA TO THE HP 5507A

The controller can write data to the HP 5507A by sending a data mnemonic followed by a numeric argument. Every data item has a specified argument range. Some data items are read-only and generate an error if written to (i.e., HP 5507A status byte). The following example loads 1.00, or the value of "Variable", into the X-axis destination register.

```
OUTPUT 703;"XDES 1.00"     or     OUTPUT 703;"XDES";Variable
```

- Numeric Argument
- Mnemonic
- String Constant
- Primary Address: HP-IB device address(factory set at 03)
- Controller-dependent "keyword" and interface select code that instructs the controller to send the information that follows the item separator ";" to the device at the specific HP-IB primary address.

To write to several data items, separate the items with semicolons. For example,

```
OUTPUT 703;"XDES 1.23;IMSK 128.0;YCLP 10"
```

- String Constant composed of three commands executed sequentially from left to right.
- Primary Address: HP-IB device address (factory set at 03).
- Controller-dependent "keyword" and interface select code that instructs the controller to send the information that follows the item separator ";" to the device at the specific HP-IB primary address.

Input data, in the form of a numeric argument, may be sent repetitively to the same mnemonic by omitting the mnemonic from all but the first programming string. The HP-IB Board will send subsequent numbers to the last mnemonic it received. For example,

```
OUTPUT 703;"XDES 1.00; 2.00; 3.00"

OUTPUT 703;"4.00; 5.00; IMSK 255; 0"
```

sequentially sends the values 1.00, 2,00, 3.00, 4.00, and 5.00 to the X-axis destination register, then 255 to the system interrupt mask, then zero to the interrupt mask. Omitting the mnemonics sent with each data string, saves the HP 5507A's time normally spent interpreting mnemonics.

READING DATA FROM THE HP 5507A

Reading data is a two-step process. First, a data item is placed in the HP-IB Board's output buffer. The controller then reads the data in the output buffer over the HP-IB bus. There are five methods of filling the output buffer, the first being to send a data mnemonic followed by a question mark.

OUTPUT 703;"XPOS?"	Places data in the HP-IB board's output buffer
ENTER 703;Variable	Controller reads buffer's contents over the HP-IB Bus.

When several data items are placed in the output buffer and not read by the controller, only the last data item placed there will be output over HP-IB when the read is finally executed. For example,

OUTPUT 703;"ISTA?;XPOS?;XDES?"	Places three data items in the HP-IB output buffer.
ENTER 703;Variable	Controller reads only the last data item entered into the buffer. In this case, the contents of the X-axis destination register is read by the controller.

The HP-IB Group Execute Trigger Message is the second method used to place data in the output buffer. When a Group Execute Trigger is received, the HP-IB Board places a fresh copy of the last item requested in its output buffer. Note that the last mnemonic sent to the HP-IB Board prior to receiving a Group Execute Trigger must be a data mnemonic, or an error will be generated. A programming example using the Group Execute Trigger Message to read the HP-IB Board's output buffer follows:

10 OUTPUT 703;"XPOS?"	Places X-axis position data in the HP-IB board's output buffer
20 TRIGGER 703	Places a new copy of X-axis position data in the HP-IB board's output buffer
30 ENTER 703;Variable	Controller reads X-position data over the HP-IB bus

The third method is similar to the Group Execute Trigger command, but provides faster transfer rates. Sending just a question mark in place of the TRIGGER speeds up program execution by allowing overlapped operation (the GET command ties up the HP-IB bus, thus pausing the program, until the HP 5507A has filled its buffer. The "?" releases the bus immediately allowing the program to continue while the HP 5507A is filling its buffer). Again, the last mnemonic sent before the "?" must be a data mnemonic or an error will be generated.

To convert the above example, change line 20 to OUTPUT 703;"?".

The Axis board's External Sample– line can also be used to fill the output buffer . It acts like a "?" providing the following three conditions are met:

1) An Axis board is set for external sampling (*EXT)
2) The HP-IB board has handshaking turned on (HSON)
3) The last mnemonic sent referred to a floating point data item.

See Page 4B-16 "Data Sample Handshaking" for further details.

The final method of filling the output buffer also applies only to floating point data items. Output formats other than FMT0 enable the HP-IB board to automatically place a copy of the last mnemonic's data in the output buffer when requested to talk. The following example illustrates this operation.

10 OUTPUT 703;"FMT1;XPOS?"	Selects Output Format 1 and fills the output buffer
20 ENTER 703;A$	Sets up the HP-IB bus and causes a new copy of XPOS to be placed in the buffer and output
30 ENTER 7;B$	Causes a new copy of XPOS to be placed in the buffer and output. No HP-IB Bus setup is needed.

Both A$ and B$ would contain XPOS data represented as 12 bytes conforming to BDFA block data format (Note — some computers may mask off bit 7 when entering data into string variables).

Numeric Input to the HP 5507A

ROUNDING

When writing to an integer data item using any numeric input format, the HP 5507A will round the input to the nearest integer. For example, each of the following Basic 3.0 statements will set the interrupt mask to 1:

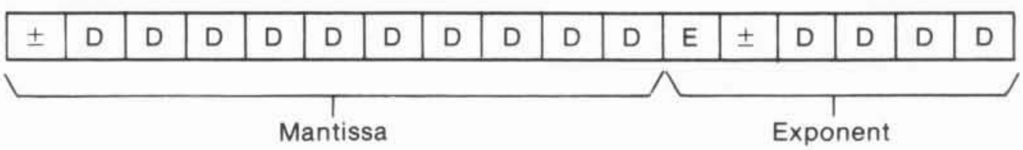
```
OUTPUT 703;"IMSK 1"

OUTPUT 703;"IMSK 1.4999999"

OUTPUT 703;"IMSK .5"
```

NUMERIC INPUT RANGE

The allowable numeric input range depends on the data item. ASCII numeric data allow inputs in the range of ±2,147,483,647 E^{-10} to +20, while IEEE-P754 double precision floating point inputs have a range of $\pm 10^{308}$. The allowable input range for a particular mnemonic is located in the mnemonic description for the board.

ASCII NUMERIC INPUT

The HP-IB Board accepts a wide variety of ASCII numeric input representations. The general form of numeric input is:



followed by an item separator (semicolon) or a string terminator (LF, LF with EOI, or DAB with EOI).

The numeric input format can be further described as follows:

- Optional "+" or '–" sign
- One to ten mantissa digits, decimal point optional
- An optional exponent composed of:

  An "e" or "E"

  An optional "+" or "–" sign

  One to four exponent digits

The magnitude of the mantissa, neglecting the decimal point, may not exceed ±2,147,483,647. The range of the exponent, regardless of the mantissa, is –10 to +20. An error message will be generated if either the mantissa or the exponent is too large.

The following are examples of correct ASCII numeric inputs:

(1) 1.23E-1

(2) +.123

(3) –0e1

(4) 1.000000000E0000

Table 4B-4 lists examples of incorrect ASCII numeric inputs:

Table 4B-4. Incorrect ASCII Numeric Inputs

Input	Problem Description
1.2+5	Embedded sign
E1	Zero mantissa digits
00000000001E1	Too many mantissa digits
-2.147483648	Mantissa magnitude (neglecting decimal) is too large
1,000	Embedded comma or European notation
1.000.000	Too many decimal points
2.2E-12	Exponent out of range

BLOCK DATA MODE NUMERIC INPUTS

For applications requiring a faster data transfer rate than may be obtained with ASCII numeric input format, the HP 5507A also accepts IEEE-728 Block Data Formats A and D. Both formats consist of eight data bytes in the IEEE-P754 standard notation for a floating point number (double precision). These formats bypass the number builder software in both the HP 5507A and the controller used. The system controller must send the EOI terminator bit with the last data byte, since linefeed terminator sensing is turned off when the "#" block data identifier is received.

The Block Data Format A input capability enables the HP 5507A to receive data from the controller formatted as shown in the following example. The example illustrates a write to the X-axis variable XDES.

Byte #	Transmitted Data	Meaning
1	"X"	ASCII Mnemonic Character
2	"D"	"
3	"E"	"
4	"S"	"
5	"#"	Block Format Specifier
6	"A"	Block Format A
7	0	Binary Length Specifier Byte 1
8	8	Binary Length specifier Byte 0†
9-16	Eight Bytes	IEEE-P754 Floating Point Data Bytes (Double Precision), MSB transmitted first, controller-generated EOI bit sent with last data byte or follow last data byte with an item separator.

†The value of the two-byte specifier must always be eight. The HP 5507A gives an error indication (i.e., Error 210) if any other value is specified.

Block Data Input Format D is similar to Format A, except that the length specifier is not required. The EOI bit must also be sent with the last data byte in order to terminate data input.

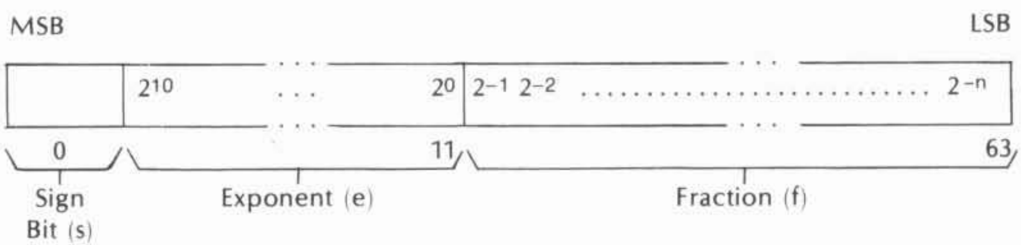
Byte#	Transmitted Data	Meaning
1	"X"	ASCII Mnemonic Character
2	"D"	"
3	"E"	"
4	"S"	"
5	"#"	Block Format Specifier
6	"D"	Block Format D
7-14	Eight Bytes	IEEE-P754 Floating Point Data Bytes (Double Precision), MSB transmitted first, controller-generated EOI bit sent with last data byte or an item separator sent after last data byte.

Multiple command information may be sent in the same string as block data numeric information simply by using a comma or semicolon as an item separator. The EOI bit must be set true and sent with the last byte in the programming string, even if a linefeed is sent as the last character byte. Linefeed sensing, space character discards, and incoming character capitalization are turned off for the remainder of the incoming character string once block data format has been detected. Therefore, spaces and lower case characters are illegal for the portion of an input string that follows the block data value.

As discussed in the ASCII Numeric Input section, the destination mnemonic for incoming numeric data need not be sent if it is the same as the last mnemonic received.

IEEE-P754 Floating Point Data Format (Double Precision)

The double precision floating point number is a 64-bit binary value formatted as follows:



1=negative
0=positive

where

"s" is the sign bit

"e" is the exponent

"f" is the 52-bit fraction

The value (v) of a double precision floating point number (x) can be computed using the following formula:

If $0<e<2047$, then $v=(-1)^s\ 2^{(e-1023)}(1.f)$.

If e=0, then v=0†

If e=2047, then v is undefined† and the HP 5507A will generate an error message.

†Not specified in IEEE-P754 standard.

The range of these numbers is approximately $\pm 10^{308}$. (See mnemonic descriptions for HP 5507A's range restrictions.)

Numeric Output from HP 5507A

INTEGER DATA OUTPUT

Certain data items may take on integer values only. Examples of an integer data item include:

(1) the instrument status byte (ISTA)
(2) the software revision byte (HREV)
(3) the interrupt mask (IMSK)

Integer data items may be output at any time, with any output format programmed. However, the data items will always have the following output format:

Leading Space or "–"	D	D	D	D	D

followed by CR byte, then LF byte with EOI bit asserted.

One to five digits

- Leading space or "–" sign
- One to five digits within the range of -32768 to +32767
- CR byte followed by LF byte with EOI bit asserted

The format commands FMT0 through FMT3, apply to floating point data only.

FLOATING POINT DATA OUTPUT

Floating point data items are output in one of four representations, depending on speed requirements and capabilities of the system controller used. Output format 0, basic ASCII output, is the easiest to use and gives reasonable speed (about 110 measurements/sec). Output formats 1, 2, and 3 are variations on a byte-mode (non-ASCII) direct data transfer. These modes avoid the floating point to ASCII format conversion and are capable of speeds to 1.5 KHz. Output format 3 is designed for data transfers to array variables in HP Series 200 computers using the BASIC 3.0 TRANSFER statement. Transfer rates are summarized in *Table 4B-5*.

Table 4B-5. HP 5507A Data-Item Transfer Rates

OUTPUT FORMAT	MNEMONIC	TRANSFER RATE	FORMAT
0	FMT0	60 to 120 Hz†	ASCII Floating Point Output
1	FMT1	1200 Hz Maximum	IEEE-728 Block Data Format "A"
2	FMT2	1350 Hz Maximum	IEEE-728 Block Data Format "D"
3	FMT3	1500 Hz Maximum	Series 200 Computer-compatible Block format
†Varies with I/O units and data value transmitted.			

While in output format 0 (power-up default), the HP 5507A will not output data until the HP-IB board's output buffer is filled using any of the following:

- A Mnemonic Request
- A Mnemonic Request followed by any number of Group Execute Triggers
- A Mnemonic Request followed by any number of question marks.
- A Mnemonic Request followed by any number of External Sample pulses (Requires HP-IB board have handshaking turned on — HSON, and an Axis board set for external sampling *EXT)

In output formats 1, 2, and 3, the HP-IB board automatically places a new copy of the last mnemonic's data into the output buffer when it is requested to talk. (See also "Reading Data from HP 5507A", Page 4B-8).

Output Format 0 Data

Output format 0 can be entered by:

- power cycling the HP 5507A system
- performing a system BOOT (Hard Reset), or
- using command mnemonic FMT0

Data is output using the following format:

Space or "–"	D	D	D	D	D	D	D	D	D	followed by the CR byte and LF byte with EOI bit asserted.

- Space or "–"
- Ten ASCII digits and decimal point, unless decimal point is last
- CR byte followed by LF byte with EOI bit asserted

Output Format 1 Data

Output format 1 is entered with the command mnemonic FMT1. In this mode, the HP 5507A outputs data using IEEE-728 Block Data Format "A" as follows:

Byte #	Transmitted Data	Meaning
1	"#"	Block Format Specifier
2	"A"	Block Format A
3	0	Binary Length Specifier Byte 1
4	8	Binary Length Specifier Byte 0
5-12	Eight Bytes	IEEE-P754 Floating Point Data Bytes (Double Precision), MSB transmitted first, HP 5507A-generated EOI bit sent with last data byte.

Output Format 2 Data

Output format 2 is entered with the command mnemonic FMT2. In this mode, the HP 5507A outputs data using IEEE-728 Block Data Format "D" as follows:

Byte #	Transmitted Data	Meaning
1	"#"	Block Format Specifier
2	"D"	Block Format D
3-10	Eight Bytes	IEEE-P754 Floating Point Data Bytes (Double Precision), MSB transmitted first, HP 5507A-generated EOI bit sent with last data byte.

Output Format 3 Data

Output format 3 can be entered with the command mnemonic FMT3. In this mode, the system controller receives the data in eight IEEE-P754 double precision, floating point data bytes. The HP 5507A transmits the most significant byte first. The EOI bit is not asserted with the last byte. This format allows direct transfers to Array Variables in HP Series 200 Computers. Output format 3 does not adhere to IEEE-728 standards.

Table 4B-6. Summary of IEEE Format Codes and HP 5507A Output Mode Mnemonics

Mnemonic	Integer Data	Floating Point Data
FMT0	NR1	NR2
FMT1	†	BDFA
FMT2	†	BDFD
FMT3	†	HP Series 200 Computer compatible block format

†HP 5507A cannot output integer data in this format and will always output it in the NR1 format.

Data Sample Handshaking

The HP-IB board uses two modes when filling its output buffer. In the power-up default mode, HSOF (handshaking off), it automatically fills its buffer when requested to output data.

In the other mode, HSON, the board waits for a backplane "data sampled" signal before filling its output buffer (only applies to floating point data items). This second mode is designed to be used with an external sample signal to lower the sampling uncertainty.

A few simple rules must be followed when using this mode.

a. The Measurement Axis being sampled must be set to the external sample mode (see *EXT in the axis board section). Failing to do so will cause the HP-IB board to lock up waiting for the "data sampled" signal, but no board will be capable of generating it (pressing the front panel reset button simulates receipt of the "data sampled" signal).

b. Generally, only one board at a time will be set to the external sample mode. Setting more boards to this mode allows any one of them to generate the "data sampled" signal, even though it wasn't providing the data requested (see Using External Sample Mode page 4D-6 in the Axis board subsection for sampling more than one axis).

c. Only position (*POS?) values should be requested. Other data requests work, but the "data sampled" signal only indicates when the position data has been updated. Also the HP-IB board only waits for this signal if the data requested is a floating point data item.

Both of these sampling modes apply equally to all four output formats. *Figure 4B-3* illustrates the relationship among the signals and events involved with reading data.

SRQ Interrupts and STATUS Bytes

HP-IB SERVICE REQUESTS

The HP 5507A can generate a "service request" when it requires the controller to take action. Service requests are generally made after the device has completed a task (such as reaching null position) or when an error condition exists.

To request service, the HP 5507A sends a Service Request message (SRQ) to the system controller. The controller detects these requests via the SRQ interrupt. After detection of the interrupt by the controller and execution of the current program line, the program branches to a routine that services the event that initiated the SRQ interrupt.

SETTING UP, ENABLING AND SERVICING SRQ INTERRUPTS (General)

In order for an HP-IB device to initiate a service routine in the controller, three prerequisites must be met:

(1) the SRQ interrupt event must have a service routine defined

(2) the SRQ interrupt must be enabled to initiate the branch to the service routine

(3) the HP-IB device must be enabled to generate an SRQ interrupt

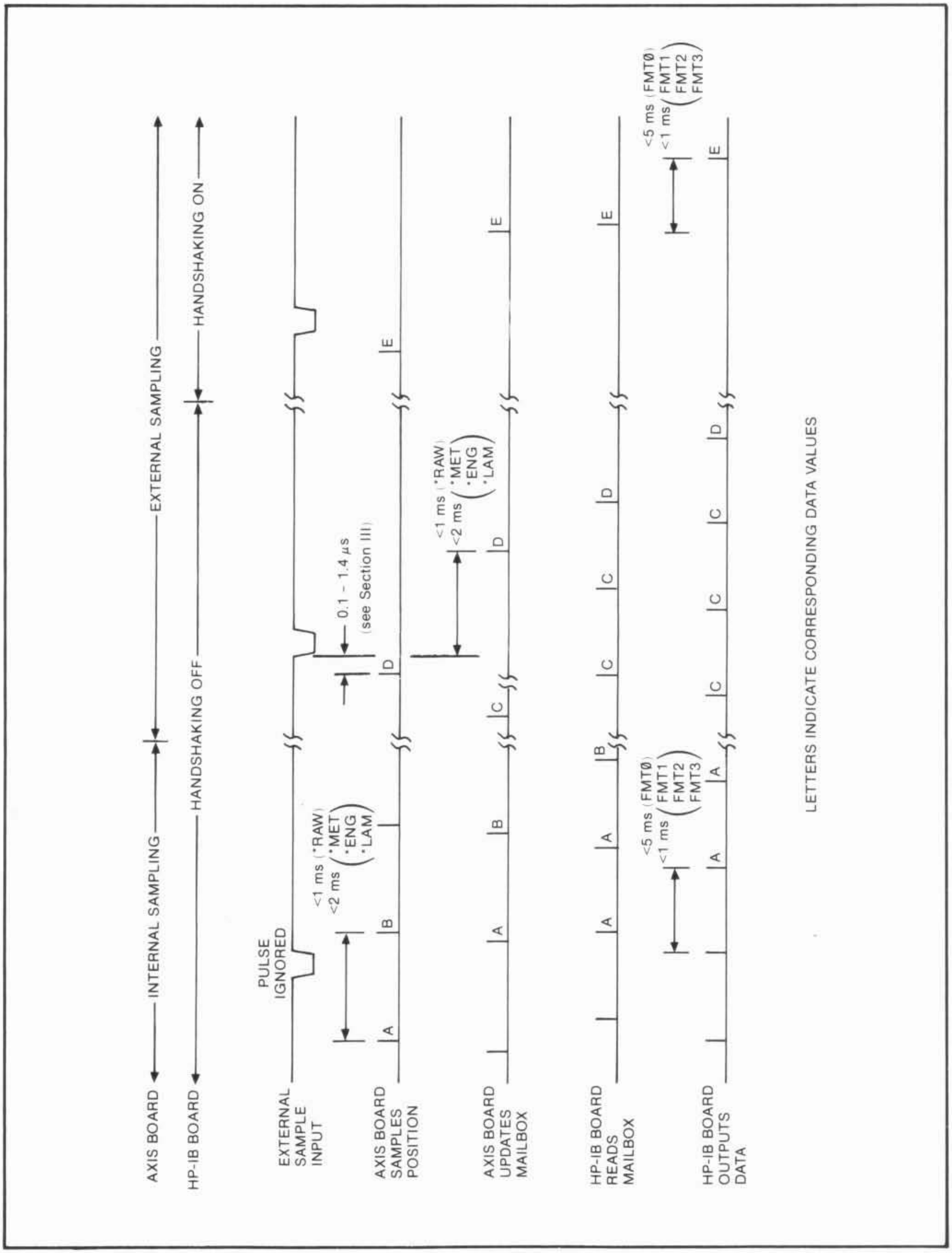


Figure 4B-3. Data Sample Handshaking

When any device generates an SRQ interrupt, the program branches to the service routine when the current line is exited. The service routine must:

- determine which device is requesting service (serial poll)
- determine what action is requested (by examining the status byte returned with the serial poll)
- clear the SRQ line (automatic with serial poll)
- perform the desired action
- re-enable SRQ interrupts
- return to the former task (if applicable)

HP 5507A STATUS BYTES

The HP 5507A has two status bytes. One, the instrument status, is returned by using the ISTA? query. The other is returned when executing an HP-IB serial poll of the HP 5507A. Both bytes are identical with one difference. Once the HP 5507A issues an SRQ interrupt, the serial poll status value which caused the SRQ to be asserted is frozen until the system controller performs the serial poll. The ISTA status byte, however, is not frozen and always reflects the current instrument operating state.

Bit positions in both bytes have the following significance:

Compensation Alert	SRQ Asserted	Error	Ready	Not Used Always=0	Path Error	Laser Reference Error	Position Null
D7	D6	D5	D4	D3	D2	D1	D0
128	64	32	16	8	4	2	1
MSB							LSB

Bit seven: Compensation Alert, is a logical "one" when the automatic compensator detects a change in compensation value outside the programmed range.

Bit six: SRQ, is "one" when the HP 5507A has issued an HP-IB SRQ to the host controller (see below).

Bit five: Error, is set by any error condition, whether a hardware fault or programming error.

Bit four: Ready, is set after the Laser Head warms up (valid reference frequency present) and the Error bit is false.

Bit three: Is not used, and is always zero.

Bit two: Path Error, is set when a measurement error occurs on any axis.

Bit one: Laser Reference Error, is set when the reference frequency signal (provided by the HP 5501/17/18 Laser Head) is interrupted.

Bit zero: Position Null, is set when all axes are in a position null condition.

ENABLING AND CLEARING THE HP 5507A's SRQ INTERRUPT

At power-up, or after a BOOT command, the HP 5507A can not generate an SRQ interrupt. This capability is enabled by using the IMSK n, Interrupt Mask mnemonic. The bits specified by the value of n enable a 0 to 1 transition of the corresponding bit in the instrument status byte to generate an SRQ interrupt. Thus the mnemonic "IMSK 33" enables the HP 5507A to assert the SRQ line on any error condition or a position null condition. Using "IMSK 0" disables the SRQ interrupt capability.

Note that IMSK0 does not cancel a current interrupt. Only a reset (front panel Reset Key, ERST mnemonic, HP-IB device clear or selected device clear) or an HP-IB Serial Poll (or a BOOT mnemonic) will clear the SRQ Interrupt. Reset, however, may not clear the condition which caused the SRQ interrupt. This will lead to the SRQ line being reasserted (ERST clears the ISTA byte, but the interrupting condition causes another 0 to 1 transition, thus setting SRQ). Serial poll just clears the SRQ line, allowing the interrupting condition to exist without generating an additional SRQ message. Executing a serial poll also returns a status byte that indicates which condition caused the interrupt (see HP 5507A's Status Bytes paragraph).

ASCII Messages from the HP 5507A

Certain HP 5507A output data are ASCII operator messages. The messages vary in length with the particular data item, and are always terminated with CR byte followed by an LF byte with EOI bit. Examples of mnemonics that return ASCII operator messages are

(1) "CNFG?" . . . . . . Returns system configuration message

(2) "ERRM?" . . . . . . Returns error message

(3) "INST?" . . . . . . Returns recognized mnemonics message

(4) "*NAM?" . . . . . . Returns board identification message

*The mnemonic prefix, representing the base address of the individual board being queried, must be included here (e.g., XNAM, PNAM, etc.).

Refer to the individual mnemonic descriptions for a more detailed description.

NOTE

The HP 5507A's current output format or handshaking mode has no effect on the ASCII messages. Output formats and handshaking effect floating point data only.

Programming Mnemonics

The following paragraphs describe the programming mnemonics executed by the HP 5507A's HP-IB board (additional subsections cover mnemonics passed to the function boards through the HP-IB board). Used in proper programming statement format, these mnemonics allow the controller to perform such functions as a system reset, output error message description, specify the floating point output format, and set the interrupt mask. Mnemonics noted as "Read-only" or "Read/Write" can by read over the HP-IB by issuing the mnemonic, followed by a "?" (e.g., HREV?).

Values can be written to "Read/Write" mnemonics by adding a numerical suffix to the mnemonic. (e.g., IMSK 160)

Mnemonics noted as "Commands" are not associated with a value that can be read or written. Issuing the command causes some action to be taken, or causes the HP-IB board to change states.

Table 4B-7 gives a summary description of these mnemonics. For a list of all mnemonics, arranged in alphabetical order, refer to Appendix A.

Table 4B-7. HP-IB Interface Mnemonic Summary

Mnemonic	Type	Response	Page Reference
BOOT	Command	The HP-IB board performs a "hard" reset (just like power up).	4B-21
CNFG	Read-only ASCII data	Returns a list of boards installed in the HP 5507A backplane.	4B-21
ERRM	Read-only ASCII data	ASCII system error message description.	4B-21
ERST	Command	The HP 5507A performs an error or "soft" reset.	4B-22
FMT0	Command	Floating Point Data is output in ASCII format. This is the power-up default format.	4B-22
FMT1	Command	Floating Point Data is output in IEEE-728 Block Data Format A.	4B-22
FMT2	Command	Floating Point Data is output in IEEE-728 Block Data Format D.	4B-22
FMT3	Command	Floating Point Data is output in a block format compatible with the HP Series 200 computers.	4B-22
HREV	Read-only Integer data	HP-IB board places its software revision date in the output buffer.	4B-22
HSOF	Command	HP-IB board automatically fills its output buffer when requested to output data (Power-up default).	4B-23
HSON	Command	HP-IB board waits for "Data Sampled" signal before filling its output buffer (used with Axis board's External Sample– input).	4B-23
IMSK	Read/Write Integer Data	The interrupt mask allows bits in the ISTA instrument status byte to generate an SRQ interrupt. Range: 0 – 255 Power-Up Default: 0	4B-23
INST	Read-only ASCII data	All recognized instruction mnemonics are output in 74 byte strings.	4B-23
IREF	Command	Switches the reference phase-locked loop to an internal 1.5 MHz system clock.	4B-24
ISTA	Read-only Integer Data	The instrument status byte always reflects the current operating status of the HP 5507A. Low-to-high transitions in one or more bits will trigger an SRQ interrupt if the corresponding bits of IMSK are set.	4B-24

BOOT

Description: BOOT

Type: Command

Upon receiving the BOOT command, the HP-IB board performs a hardware "hard" reset, identical to cycling AC power on-to-off-to-on. The system executes the normal power-up self test and initialization routine.

BOOT sets the HP-IB board variables to the following states:

- Input buffer: cleared
- Output buffer: cleared
- Mnemonic display pointer: reset to top of list
- SRQ interrupt mask (IMSK): cleared
- Handshake mode: set to off (i.e., HSOF)
- Floating Point data output mode: FMT0
- Instrument Status Byte (ISTA): updated to a value reflecting no errors

CNFG

Description: Configuration

Type: Read-only ASCII data

CNFG? returns a list of all boards installed in the HP 5507A backplane. The list length varies with the number of boards installed, but has a maximum of 64 characters plus the <CR>, <LF> with EOI terminator.

```
DIM Config$[64]
OUTPUT 703;"CNFG?"
ENTER 703;Config$
DISP Config$
```

Displayed output: * HP-IB   V COMP   X AXIS

Note that the HP-IB board address is indicated by an asterisk (*), because it is not addressable on the backplane.

Function boards that fail their power-up self test appear in the displayed configuration string as a series of dashes rather than the usual four-character name. For example, a configuration string of

* HP-IB   V COMP   X ————

means that (axis) board X has failed its power-up self test.

ERRM

Description: Error Message

Type: Read-only ASCII data

ERRM is the ASCII system error message. ERRM is always 51 characters in length (padded with trailing spaces), plus the <CR>, <LF> with EOI terminator. The ERRM data item contains error source information, error number, and an English description of the error. Here are some examples of the messages returned after sending an ERRM? data request:

- OK
- * HP-IB ERROR 300: Unrecognized mnemonic.
- X AXIS ERROR 445: Clip limit entry out of range.
- V COMP ERROR 880: Sensor channel out of range.

ERST

Description: Error Reset

Type: Command

Sending the ERST command to the HP 5507A performs a "soft" reset, identical to that performed by pressing the front panel Reset key. The ERST command holds the HP-IB port inactive for about 150 milliseconds to allow any board with an error condition to complete reset activity.

The "soft" reset sets the HP-IB board variables to the following states:

- Mnemonic display pointer: reset to beginning of list
- Error LED drive: reset
- HP-IB SRQ Line: Cleared
- ISTA: updated to a value reflecting no errors

FMT0 - FMT3

Description: Output Formats 0 through 3

Type: Command   Power-up Default: FMT0

FMT0 through FMT3 set the floating point output data transmission formats, as outlined in the Numeric Data Output paragraphs of this document.

Table 4B-8. IEEE Format Codes and HP 5507A Output Mode Mnemonics

Mnemonic	Integer Data	Floating Point Data
FMT0	NR1	NR2
FMT1	†	BDFA
FMT2	†	BDFD
FMT3	†	HP Series 200 Computer compatible block format

† HP 5507A cannot output integer data in this format and will always output it in the NR1 format.

HREV

Description: HP-IB Board Software Revision Date

Type : Read-only integer data

Upon receiving the HREV? data request, the software revision date of the HP-IB board is placed in the output buffer. The revision date is in the following format:

<space>DDDD

Where DDDD is the HP standard date code (e.g., date code 2432 means the 32nd week of 1984).

HSOF

Description: Sample Handshaking OFF

Type: Command

HSOF turns off data sample handshaking. With handshaking turned off (power up default), the HP-IB Board automatically fills its output buffer when data is requested (e.g., mnemonic is followed by a ?) This action results in about 2 ms of sampling uncertainty. (If stage is moving at 10.0 cm/s, then because the sample occurred anywhere in a ±2 ms window, the value returned by *POS? could differ from actual position by (±2 ms) × (10.0 cm/s) = ±0.020 cm. This difference goes to the accuracy limits when stage is stationary.)

HSON

Description: Sample Handshaking On

Type : Command

HSON turns on Data Sample Handshaking. This mode is used in conjunction with the axis board's External Sample– input to lower the sampling uncertainty to 1.4 μs (see Section III).

When handshaking is in effect, the HP-IB board will not fill its output buffer with floating point data until the backplane "Data Sampled" line pulses low. The HP 10932A Axis board, if set to external sampling (*EXT), pulses this line after updating the position (*POS?) value in response to an external sample input. The front panel Reset key also enables the HP-IB board to fill its output buffer, but the data fetched will probably be old.

It is important not to issue sample pulses faster than the HP-IB board can send the sampled data, otherwise samples will be missed. Sample pulses issued prior to turning Handshaking on are ignored by the HP-IB Board.

ASCII and Integer data items are unaffected by HSON and always automatically fill the output buffer when requested.

IMSK

Description: Interrupt Mask

Type: Read/Write Integer Data

Data Range: 0 - 255 Power-up Default: 0

The Interrupt mask allows bits in the ISTA status byte to interrupt the system controller. A one in a particular IMSK bit position enables a 0 to 1 transition in the corresponding bit in the ISTA byte to turn on the HP-IB SRQ message to the external controller. See the SRQ interrupts and STATUS Byte paragraphs (page 4B-16) for a more detailed description of the HP-IB service request message.

INST

Description: List of Instruction Mnemonics Recognized by the HP 5507A

Type: Read-only ASCII data.

INST? returns all the instruction mnemonics the HP 5507A can respond to, 15 at a time. Spaces separate the mnemonics on the returned line, for a total of 74 characters plus the <CR>, <LF> with EOI terminator. Successive INST? requests return more lines of the mnemonic list until the list is complete. At this point, further INST? requests begin to repeat the list. Pressing the front panel Reset key or executing either a ERST or BOOT command, initializes the INST? list pointer back to the list's beginning.

IREF

Description: Internal Reference Signal

Type: Command

IREF is a special test mnemonic used to switch the reference frequency phase-locked loop to an internal 1.5 MHz system clock. The HP 5507A must be power-cycled or the BOOT command sent over HP-IB, in order to reset the loop to normal operation.

ISTA

Description: Instrument Status Byte

Type: Read-only Integer data

The status byte always reflects the current operating state of the HP 5507A. Low-to-high transitions in one or more bits of the status byte trigger an SRQ interrupt if the corresponding bit(s) of the SRQ interrupt mask IMSK are set. The interrupt will not recur until the interrupting condition is reset and again set. SRQs are cleared by reading the status byte with a serial poll, sending an ERST command to the HP 5507A, pressing the front panel Reset key, or executing a device clear. Events causing an SRQ interrupt which are not cleared by a "soft reset", trigger another SRQ interrupt when the reset is completed.

SRQ triggers are ignored during the time between an initial SRQ and SRQ clearing via HP-IB serial poll.

See the SRQ interrupt and STATUS Byte paragraphs for a more detailed description of the HP-IB service request message.

Compensation Alert	SRQ Asserted	Error	Ready	Not Used Always=0	Path Error	Laser Reference Error	Position Null
D7	D6	D5	D4	D3	D2	D1	D0
128	64	32	16	8	4	2	1
MSB							LSB

HP-IB Board Reset Response

HARD RESET

The variables and mode conditions listed in *Table 4B-9* are set when the system is forced into the "hard reset" cycle. The user may initialize "hard reset" by:

- Power-cycling the HP 5507A Laser Transducer (i.e., slowly cycling the AC power from on-to-off-to-on)
- Sending the BOOT command to the HP-IB board
- Toggling the Internal Master Reset Switch located on the HP-IB board.

Table 4B-9. HP-IB Board Hard Reset Response

Variable or Mode	Mnemonic	Reset Variable or Mode to . .
Input Buffer	——	Cleared
Output Buffer	——	Cleared
Instruction Mnemonic Output Pointer	INST	Reset to top (beginning) of list
Interrupt Mask	IMSK	Cleared
Sample Handshake	HSOF, HSON	Set to HSOF (Handshaking off)
Floating Point Output Format	FMT0-FMT3	Set to FMT0 (Output Format 0)
Instrument Status Byte	ISTA	Zeroed

In addition, "hard reset" initiates a system hardware self-test (requires ~20 seconds to complete), and a Laser Head warm-up waiting period.

SOFT RESET

The "soft reset" cycle may be initialized by performing one of the following:

- Depressing the front panel RESET key
- Sending the ERST command to the HP-IB board
- Sending the HP-IB device-independent commands Device Clear (DCL) or Selected Device Clear (SDC).

The "soft reset" will perform the following:

- Instruction Mnemonic Output pointer for INST? query is reset to top (beginning) of list
- Instruct the HP-IB board to attempt to reset any function board errors
- Status byte (ISTA) is updated
- HP-IB SRQ line is cleared.
- Front Panel Error LED is turned off.

Error Messages and Front Panel Annunciators

The error messages, combined with the front panel annunciators (LEDs), provide assistance with both system programming and hardware problems. An understanding of LED indications and sequences are covered briefly in the following paragraphs.

LASER ON (Yellow)	Always lit when the HP 5507A power is on. Meets a safety regulatory requirement to warn the operator that the laser may be on.
LASER LOCKED (Green)	Illuminates when the Laser Head has reached proper operating temperature and has locked the reference signal.
MEASUREMENT SIGNAL ERROR (Red)	Any error involving the laser's measurement signal will cause this LED to illuminate.
SYSTEM ERROR (RED)	Indicates system errors, such as reference or measurement signal glitches, incorrect programming strings, etc.
TALK (Green)	Indicates the HP 5507A is addressed to talk and is currently transmitting data.
LISTEN (Green)	Indicates the HP 5507A is addressed to listen and is currently receiving data.

SRQ (Green)	Indicates a service request condition exists.

At power-up or following a "hard reset", the LEDs will undergo the following unique sequencing cycle:

Power-up or "Hard Reset"	All front panel LEDs illuminate on then off, with the LASER LOCKED LED remaining on a bit longer than the other LEDs. In the next 20 seconds, the HP-IB board executes self-tests and the flashing LEDs are indicative of the tests' progress.
Laser Warm-up Period	During the period following the HP-IB board self-tests and preceding the Laser Head reaching proper operating temperature, the TALK, LISTEN, and SRQ LEDs will blink sequentially until proper operating temperature has been reached.
Laser Reference Stability	When the Laser Head reaches proper operating temperature and the laser reference signal stabilizes, the LASER LOCKED LED illuminates and the TALK, LISTEN, and SRQ LEDs no longer blink sequentially. The HP-IB now performs a "soft reset" to initialize all system boards.

ERROR INDICATION

The SYSTEM ERROR LED remains off if the system operates properly. If an error is detected in the system — be it a hardware, programming, or data entry error — the HP 5507A's operation is not suspended. Internal software enables the user to interrogate the system via the controller as to the source of the error. The ERRM? data request returns an ASCII data item that contains the following information:

- Error source information
- Error number
- Short description of the error.

After eliminating the cause of the error, the error message can be cleared by initializing a system "soft reset".

HP-IB BOARD ERROR MESSAGES

-500 Unidentified System Error

This error occurs when the backplane Error- line is pulled low and all function boards have a zero *STA status byte. This will occur when customer-installed equipment pulls the error line low, or in the event of a mailbox or error line driver hardware failure on any board.

-201 Numeric Output Conversion Error

This error occurs when the HP-IB board tries to output an integer larger than $\pm(2^{32} - 1)$.

-101 System Error

The HP-IB board sources this error upon finding a malfunction on another board's mailbox. This could happen when there is a hardware problem. Check all boards in the backplane.

-100 No Boards Found During Boot

This happens when the HP-IB board is unable to find any boards on the backplane at power-up or may indicate a hardware problem with the backplane drivers.

100 No Active Listeners Present

Occurs when the HP-IB board is addressed to talk, but there are no active listeners present. This most often happens when the controller is reset during an HP-IB data transmission.

200 Input Format Error

This error means that the HP-IB board was unable to properly parse the input string into mnemonics and data. Typically, this error occurs when an incorrect separator is used between mnemonics (i.e., a character other than a comma or semicolon).

202 No Data Available for Output.

Occurs when addressing the HP-IB board to talk, but no data exists in the output buffer. This may happen if the HP 5507A is addressed to talk without first sending a valid data request mnemonic (like "XPOS?").

203 Input String More Than 80 Characters in Length

The HP-IB board can only accommodate a string of 80 input characters at a time.

210 Numeric Input Format Error

The numeric portion of an input string does not conform to format guidelines.

211 Numeric Entry Out of Range

An attempt was made to write a number outside the limits of the intended variable.

212 Block Input Format/Range Error

An input data item did not conform to the selected block format ("#A" or "#D" select which format will be used for the data item).

300 Unrecognized Mnemonic

An input string was not recognized as a valid mnemonic. Allowable mnemonics may be read using the INST? instruction mnemonic list data request.

301 Data Mnemonic Used as Command

A data item mnemonic was sent to the HP 5507A without the required query ("?") or numeric suffix.

302 Command Mnemonic Used as Data Mnemonic

A command mnemonic was sent to the HP 5507A with a "?" or numeric suffix. Command mnemonics can not have a suffix.

303 Write to Read-only Variable

An attempt was made to write a number to a read-only data item (e.g. the ISTA status byte). Read-only variables may not be written to.

450 Laser Reference Unlocked

Reference frequency errors, which affect all measurement boards, are reported by the HP-IB board. This error indicates a glitch or dropout in the master reference input from the attached laser head. All measurement data is lost when this error occurs.

Table 4B-10. HP 5507A HP-IB Board Error Message Summary

Error	Description
-500	Unidentified System Error
-201	Numeric Output Conversion Error
-101	System Error
-100	No Boards Detected During Boot
100	No Active Listener is Present
200	Input Format Error
202	No Data Available for Output
203	Input String More Than 80 Characters Long
210	Numeric Input Format Error
211	Numeric Entry Out of Range
212	Block Input Format/Range Error
300	Unrecognized Mnemonic
301	Data Mnemonic Used as a Command
302	Command Mnemonic Used as Data
303	Write to Read-only Variable
450	Laser Reference Unlocked

SECTION IV
SUBSECTION C
RESERVED FOR FUTURE USE

SECTION IV

SUBSECTION D
HP 10932A AXIS BOARD

CONTENTS

SECTION IV

SUBSECTION D
HP 10932A AXIS BOARD

HP 10932A AXIS BOARD

The axis board translates fringe counts from an HP 10780A Receiver or an HP 5518A internal receiver into useful position (31 bits), position error (32 bits), and velocity (±5V analog) signals.

Every board in the HP 5507A backplane is individually programmed. I/O units (Metric, English, wavelength, or raw counts), optics type (linear, single beam, plane mirror, or differential) and compensation factors may be selected independently for each axis. Additionally, measurement errors on one axis may be reset without affecting other axes.

ADDRESSES

The axis board may be set to backplane address S, T, U, V, W, X, Y, or Z by setting a dip switch at the top edge of the board. The least significant address bit is located at the end of the switch closest to the front of the HP 5507A. Logical "ones" are indicated when the individual switch levers point away from the printed circuit board.

Table 4D-1. Axis Board Address Switch Settings

Switch Setting		Mnemonic Prefix	Notes
MSB	LSB		
0000	0000	S	These addresses overlap with the Compensation Board's Address space. DO NOT set an Axis board and a Compensation Board to the same address.
0010	0000	T	
0100	0000	U	
0110	0000	V	
1000	0000	W	Factory setting for fourth axis board installed in a system.
1010	0000	X	Factory setting for axis board installed in a single-axis system.
1100	0000	Y	Factory setting for second axis board installed in a system.
1110	0000	Z	Factory setting for third axis board installed in a system.
Note: Logical "ones" are indicated when the switch levers point away from the circuit board. Logical "zeroes" are indicated when the switch levers point toward the circuit board.			

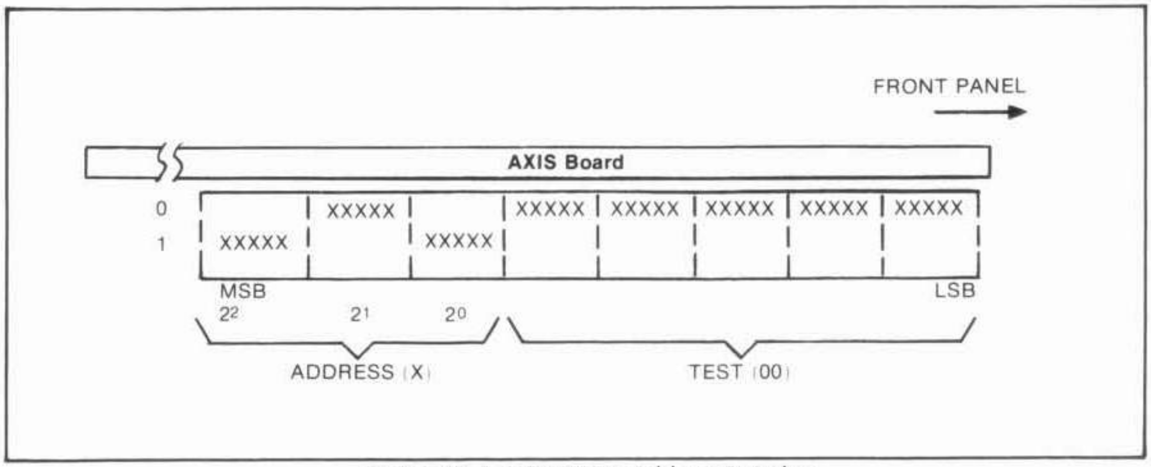


Figure 4D-1. HP 10932A Address Switches

Mnemonics Overview

AXIS BOARD SETUP COMMANDS

The following set of commands is used to setup (initialize) the axis board. The mnemonics listed in the left-hand column of *Table 4D-2* represent variables and modes that are defaulted to when the HP 5507A is power-cycled or when the BOOT command is sent to the HP-IB board. Whether these mnemonics are sent depends on what task the HP 5507A is to perform. For example, if a system is configured using linear optics, English output and signed-magnitude error output, then the default variables and modes must be changed. The following command string could be used to perform this task: "XOP0;XENG;XSMG".

Table 4D-2. Axis Board Setup Commands

Mnemonics		Description	Page Reference
BOOT or Hard Reset Condition	**Alternate Variable or Mode Condition**		
*EM0	*EM1	Selects Error Mode 0 or 1.	
		When in Error Mode 0, measurement errors from a particular axis will shut off the Drive Enable Out– line.	4D-9
		When in Error Mode 1, any HP 5507A error will shut off the Drive Enable Out– line.	4D-10
*MET	*ENG, *LAM, or *RAW	Selects Position Output units.	
		*ENG sets the I/O units to compensated inches.	4D-10
		*MET sets the I/O units to compensated millimeters.	4D-11
		*LAM sets the I/O units to compensated raw counts (λ/64 or λ/128 depending on the optics used).	4D-11
		*RAW sets the I/O units to uncompensated raw counts.	4D-13
*INT	*EXT	Selects Sample Trigger source.	
		*INT enables the internal (software) sample triggering source for the position data (*POS).	4D-11
		*EXT enables the external (hardware) sample triggering source for the position data (*POS).	4D-10
*MEX	*MIN	Selects measurement input source.	
		*MEX switches the axis measurement input channel to the external measurement input channel (HP 10780A Receiver).	4D-11
		*MIN switches the axis measurement input channel to the internal measurement input channel (HP 5518A measurement frequency output).	4D-11
*OP1	*OP0 or *OP2	Selects optics resolution.	
		*OP0 informs the axis board that Linear optics are used with this axis. (λ/64 resolution)	4D-12
		*OP1 informs the axis board that Plane Mirror optics are used with this axis. (λ/128 resolution)	4D-12
		*OP2 is not currently used.	4D-12
*TCP	*SMG	Selects Position Error Output format.	
		*TCP switches the hardware Position Error lines to two's complement form.	4D-15
		*SMG switches the hardware Position Error lines to signed-magnitude format.	4D-14
The asterisk (*) preceding the mnemonic denotes the address of the selected axis board (S, T, U, V, W, X, Y, or Z).			

AXIS BOARD SETUP/OPERATION MNEMONICS

Table 4D-3 summarizes additional mnemonics used during the axis board's initialization and during normal operation. All entries, except for *PRE, are initialized to zero and require a data entry (numeric argument) to change this value. *CLP and *NUL are used to match the axis board outputs to the servo system's input requirements. *DES initiates stage movement, and when used in conjunction with *PRE, aids in deadpath compensation.

Table 4D-3. Axis Board Setup and Operation Mnemonics

Mnemonic	Type	Response	Page Reference
*CLP	Read/Write Integer Data	Sets the Position Error Output bit clip level. (*Table 4D-6*). Range: 0, 8–20 Power-Up Default: 0	4D-8
*DES	Read/Write Floating Point Data	Loads the axis board's destination register. (Units must correspond to programmed Position Output Units, *ENG, *MET, *LAM or *RAW). Range: ±5310 mm (plane mirror optics) Power-Up Default: 0	4D-9
*NUL	Read/Write Integer Data	Defines the Position Error Null range. (*Table 4D-7*). Range: 0–12 Power-Up Default: 0	4D-12
*PRE	Command	Presets the position counter to the value currently in the axis board's destination register. (5 least significant bits are not changed).	4D-13
*TCN	Read/Write Floating Point Data	*TCN is the wavelength-of-light and material temperature compensation number. Range: 0.99–1.01 Power-Up Default: 1.0	4D-15
The asterisk (*) preceding the mnemonic denotes the current address of the selected axis board (S, T, U, V, W, X, Y, or Z).			

AXIS BOARD SERVO OPERATION MNEMONICS

The mnemonics listed in *Table 4D-4* are sent to the axis board during normal operation. *ZRO, or *PRE in conjunction with *DES, is used to recover from a measurement error detected by sending the *STA? or ISTA? queries. *DR1 and *DR0 turn the Drive Enable Line on and off. *POS? returns the current axis position in the selected output units.

Table 4D-4. Axis Board Servo Operation Mnemonics

Mnemonic	Type	Response	Page Reference
*DR0	Command	Turns the Drive Enable Out– off and sets the Position Error outputs low. (Power-Up Default.)	4D-9
*DR1	Command	Sets the Drive Enable Out– line to the active state (low) and enables the Position Error output lines. (See also Page 3-13, Drive Enable Out–)	4D-9
*POS	Read-only Floating Point Data	Returns the position counter's value in the selected I/O units (*RAW, *LAM, *ENG, *MET).	4D-13
*STA	Read-only Integer Data	*STA is the axis board's status byte. Nonzero values indicate that an error condition exists. (See *Table 4D-9*.)	4D-14
*ZRO	Command	Resets the position counter to zero.	4D-15

MISCELLANEOUS AXIS BOARD MNEMONICS

The following mnemonics are not generally used for programming, but can be helpful when installing and configuring a laser position transducer.

Table 4D-5. Miscellaneous Axis Board Mnemonics

Mnemonic	Type	Response	Page Reference
*NAM	Read-only ASCII Data	Requesting *NAM from the axis board returns the string "AXIS<CR><LF> and EOI."	4D-12
*REV	Read-only Integer Data	Returns the axis board's software revision date.	4D-14
*TST	Read/Write Floating Point Data	A special test mnemonic that switches the axis measurement input between the normal measurement inputs (as selected by *MIN and *MEX) and three fixed test frequencies of 1.0 MHz, 1.5 MHz, and 2.0 MHz. Range: ±0.24, 0.76–2.24 Power-Up Default: 0.00	4D-15

The "*" preceding the mnemonic denotes the address of the selected axis board (S, T, U, V, W, X, Y, or Z).

General Programming Requirements for the Axis Board

Based on the previous paragraphs, the following steps outline the general programming requirements for the axis board.

Operation	Send Command
1. Specify the type of optics used on each system axis.	*OP0, *OP1, or *OP2
2. Set the Error Handling Mode for each axis.	*EM0 or *EM1
3. Select the HP-IB I/O units for each system axis.	*RAW, *LAM, *ENG, or *MET
4. Select axis measurement source: HP 10780A or HP 5518A.	*MEX or *MIN
5. Set hardware output format (signed-magnitude or two's complement)	*SMG or *TCP
6. Select internal or external sampling for *POS data.	*INT or *EXT
7. Set clip and null range.	*CLPn and *NULn
8. Set total compensation number.	*TCNn
9. (a) Reset the appropriate axis position counter to zero.	*ZRO
(b) Set appropriate axis position counter to deadpath value.	*DESdp and *PRE
10. Enable position error hardware outputs.	*DR1
11. Input desired axis position destinations.†	*DESn
12. Read the derived axis position.†	*POS?
13. Repeat steps 8, 11, and 12 as required.	

†If the dead path has been preset per step 9b, then *DES = desired position + dead path, and true position = *POS − dead path.

Using the External Sample Mode

There are two ways to use the axis board's external (hardware timed) sampling mode. One is with the HP-IB board's sample handshake turned on (HSON). The other is with it turned off (HSOF). In either case, the axis board must be set for external sampling with the *EXT command.

The first method is used with only one axis at a time. The desired axis is placed in external sampling mode, the HP-IB board is set for sample handshaking on, and desired data is requested (*POS?). Then, until instructed otherwise, each pulse on the external sample line causes:

a. The position counter's value to be latched in a register (sampled).

b. The HP-IB board to fill its output buffer with the requested data (specified by last mnemonic sent to HP 5507A).

c. The HP-IB board to output the data over the HP-IB bus (provided it is addressed to talk and there is an active listener on the bus).

The maximum sampling rate is determined by both the HP-IB data transfer rate (depends on output format and controller used) and the axis board's update rate (depends on units selected — *ENG, *LAM, *MET, *RAW).

Sampling frequencies higher than this maximum will still "work", however some pulses will not trigger the sequence of events. These extra pulses will be ignored.

To exit this first mode of data sampling and transfer, the HP-IB board's sample handshaking must be turned off (HSOF) and the axis board must be returned to internal sampling (*INT).

The second use of external sampling allows sampling of more than one axis at a time. In this case the HP-IB sample handshake is cycled on and off and all the desired axis boards are placed in external sample mode. Each external sample pulse causes all axis boards to latch their position counter's value into registers and triggers reading the first axis. However, now each data item must be specifically requested. (i.e., HSON;XPOS? — read data — HSOF;YPOS? — read data — ZPOS? — read data — HSON;XPOS? .....).

The sampling frequency depends on the same parameters as in the first method, however the maximum rate is slower due to the required data requests. The benefit is the temporal accuracy in sampling all axes simultaneously.

Exiting this mode is done by sending *INT to all axis boards.

Compensating for Deadpath

Any deadpath (see Section V) should be compensated for to minimize measurement inaccuracies due to changing environmental conditions. The *PRE in concert with the *DES mnemonics allow partially automatic deadpath compensation. The overall deadpath equation can be expressed as:

$$\text{True Position} = \left(\text{Accumulated Counts} + \text{Deadpath Counts}\right) \times \left(\text{Total Compensation Number}\right) \times \left(\text{Unit Conversion Constant}\right) - \left(\text{Deadpath in Selected Units}\right)$$

By initially loading the counter with the deadpath value, the first addition is automatic and the multiplication is done by the HP 5507A (see *POS). The only requirement of the external controller is to subtract the deadpath value from the *POS value or add it to the *DES value to obtain the true position or set the desired position. The penalty is that the measurement range has been offset by the deadpath distance (e.g., if deadpath equals 0.5m, then measurement range with plane mirror optics is –5.5m to +4.5m.) Also, because the counter can only be preset to resolutions of $\lambda/2$, $\lambda/4$ or $\lambda/8$ (depends on the optics used), the *POS? data request should be used immediately after the *PRE mnemonic to determine the deadpath value actually set.

To compensate for deadpath without presetting the counter, the following equations must be used by the external controller:

True Position = *POS + $(TCN_1 - TCN_0)$ * (DP in selected units)/(TCN_0)

and *DES = Desired Pos − $(TCN_1 - TCN_0)$ * (DP in selected units)/(TCN_0)

where DP = Deadpath

TCN_1 = current Compensation Number

TCN_0 = initial Compensation Number

Using the *TST Mnemonic

There are two primary uses of the *TST mnemonic. The first is for general testing and requires that the IREF mnemonic also be issued. The second sets up a multiaxis HP 5507A for single axis (or fewer axes than the number of installed axis boards) use.

Sending "IREF;XTST 1.5;YTST 1.5" allows software testing a two-axis system without a laser or receivers connected to the HP 5507A. The command string sets both the reference and the measurement inputs to 1.5 MHz, causing the HP 5507A to "think" it has a laser head and two receivers connected. Using 1.0 to 2.0 MHz for the measurement test frequency will cause the counters to count down or up at 0.5 MHz respectively (counters will overflow in about 68 seconds).

Sending "YTST 1.5;ZTST 1.5" prevents the Y and Z axes of a three-axis system from generating a Measurement Signal Error. This allows operation of the system as if only the X axis board is installed ("YZRO;ZZRO" must be sent once per minute to prevent the counters from overflowing and signalling a System Error).

Axis Board Mnemonics Reference

The following mnemonics are recognized by the axis board. The "*" preceding them denotes the address of the selected board, which can be "S", "T", "U", "V", "W", "X", "Y", or "Z". It will be factory set per *Table 4D-1*.

Mnemonics noted as "Read-only" or "Read/Write" can by read over HP-IB by issuing the mnemonic, followed by a "?" (e.g., XREV?).

Values can be written to "Read/Write" mnemonics by adding a numerical suffix to the mnemonic. (e.g., XDES 75.0)

Mnemonics noted as "Commands" are not associated with a value that can be read or written. Issuing the command causes some action to be taken, or causes the axis board to change states.

***CLP**

Description: Position Error Output Clip Level

Type: Read/Write Integer Data

Data Range: 0, 8-20 Power-up Default: 0

*CLP sets the number of Position Error output bits affected by clipping. A *CLP value of zero turns clipping off. For nonzero values, the selected number of lower order bits function normally until their range is exceeded. At that point they retain their maximum (or minimum) value until the Position Error is again within their range (higher order bits are unaffected). See also paragraph on position error outputs in Section III.

Table 4D-6. Clipping Values

*CLP Argument Value	Position Error Bits Affected by "Clipping"
0	NONE
8	8 lowest bits
9	9 lowest bits
10	10 lowest bits
11	11 lowest bits
12	12 lowest bits
13	13 lowest bits
14	14 lowest bits
15	15 lowest bits
16	16 lowest bits
17	17 lowest bits
18	18 lowest bits
19	19 lowest bits
20	20 lowest bits

Clipping has no effect on the axis position (*POS) as read out over HP-IB.

***DES**

Description: Destination Register

Type: Read/Write Floating Point Data

Data Range:
English I/O units† : ±209 inches
Metric I/O units† : ±5310 millimeters
Raw or λ I/O : ±1,073,741,823 counts

†Values are for plane mirror interferometer. Range doubles if linear or single beam optics are used.

Power-up Default: 0

Writing to *DES loads the destination register with the following value:

Destination Register Value = (*DES) × (1/*TCN) × (1/units conversion constant)

unless the axis is placed in raw counts mode with the *RAW command, in which case the destination register is loaded directly with *DES.

***DR0**

Description: Drive Enable Out– off

Type: Command

*DR0 may be used at any time to turn off the Drive Enable Out– line (see Section III) and force the Position Error outputs to zero. (The Position Error outputs won't go to zero if the Error Hold– input is being held low, thus freezing them.)

The following conditions also toggle the Drive Enable Output false (high):

1) Power-up initialization or system BOOT command.

2) A measurement error on this axis.

3) Position counter over/underflow error on this axis.

4) If in Error Mode 1 (*EM1), any other system or programming error.

In addition, the Drive Enable Out– line will be held high (false) whenever the Drive Enable In– line is false (high).

***DR1**

Description: Drive Enable Out– on

Type: Command

*DR1 may be used at any time to restore the Drive Enable Out– line to the active state. However, this command will have no effect if other conditions (see above) force Drive Enable Out– false (high). When the Drive Enable Out– line becomes active (low) again, the Position error outputs will jump back to their correct value after 2 Error Clock periods (see Section III).

***EM0**

Description: Error Handling Mode 0

Type: Command

*EM0 is used to place the axis board in Error Handling Mode 0. Only measurement errors from this axis or a *DR0 command will shut off Drive Enable Out– while in Error Mode 0. The axis board powers up in the Error Mode 0 state.

*EM1

Description: Error Handling Mode 1

Type: Command

*EM1 is used to place the axis board in Error Handling Mode 1. In Error Mode 1, any HP 5507A error (other axis error, programming error, etc.) will shut off Drive Enable Out– until it is again set with *DR1.

*ENG

Description: Compensated English I/O Units

Type: Command

This command, sets an axis I/O units to compensated (*TCN) inches. Each axis may be set to different I/O values (see *MET, *LAM, and *RAW).

*EXT

Description: External Sample Triggering Source

Type: Command

This command is used to change from internal software sampling to an external (hardware) sample triggering source for the software accessible position data (*POS). This command does not affect the Position Error outputs on either the rear panel or the axis inter-card connectors.

When an axis board is in external sampling mode, the value returned with the *POS mnemonic is only updated on the falling edge of the External Sample– Input. Transitions on this input which occur before the board is placed in external sample mode, and transitions which occur more rapidly than the axis board can update *POS, are ignored.

***INT**

Description: Internal Sample Triggering Source

Type: Command

This command is used to change from an external (hardware) sample triggering source to internal software sampling for the software accessible position data (*POS). This command does not affect the rear panel or internal Position Error outputs.

In internal sampling mode, position data in *POS is updated as often as possible via a continuously cycling software loop (>500 Hz compensated data update rate, or >1.3 kHz in *RAW units mode).

The axis board always powers up in the internal sample mode.

***LAM**

Description: Compensated Raw Count I/O Units

Type: Command

This command sets the I/O units for this axis to compensated (*TCN) raw counts. Each count represents $\lambda/64$ or $\lambda/128$ (depends on optics) with λ equal to the vacuum wavelength. Each axis may have different I/O units (see *ENG, *MET, *RAW).

***MET**

Description: Compensated Metric I/O Units

Type: Command

This command sets the I/O units for an axis to compensated (*TCN) millimetres. Each axis may have different I/O units (see *ENG, *LAM, *RAW). The axis board powers up in metric units.

***MEX**

Description: External Measurement Input Channel

Type: Command

*MEX is used to switch the axis measurement input from the internal measurement input channel (HP 5518A Laser Head) to the external measurement input channel (HP 10780A Receiver).

The axis board always powers up in the external measurement input mode.

***MIN**

Description: Internal Measurement Input Channel

Type: Command

*MIN is used to switch the axis measurement input from the external measurement input channel (HP 10780A Receiver) to the internal measurement input channel (HP 5518A Laser Head).

*NAM

Description: Board Name

Type: Read-only ASCII Data

Requesting *NAM from the axis board returns the string "AXIS<CR><LF>& EOI".

*NUL

Description: Position Null Mask Specifier

Type: Read/Write Integer Data

Range: 0-12 Power-up Default: 0

*NUL sets the Position Error range which sends the Position Null– output line low. The null range differs slightly for two's complement and sign-magnitude output formats (*Table 4D-7*).

The Position Null output line is true (low) whenever the position error is smaller than the limit set by the Null Mask Specifier (*NUL).

Table 4D-7. Position Null Limits

*NUL Value	Position Null Limits		Approximate Null Range in Signed-Magnitude Format for Plane Mirror[1] Optics	
	Signed-Magnitude	Two's Complement	English (μ inch)	Metric (micron)
0	mag(E) < 1[2]	−2 < E < 1	0.2	0.005
1	mag(E) < 2	−3 < E < 2	0.4	0.010
2	mag(E) < 4	−5 < E < 4	0.8	0.020
3	mag(E) < 8	−9 < E < 8	1.6	0.040
4	mag(E) < 16	−17 < E < 16	3.1	0.079
5	mag(E) < 32	−33 < E < 32	6.2	0.158
6	mag(E) < 64	−65 < E < 64	12.5	0.316
7	mag(E) < 128	−129 < E < 128	24.9	0.633
8	mag(E) < 256	−257 < E < 256	49.8	1.266
9	mag(E) < 512	−513 < E < 512	99.7	2.532
10	mag(E) < 1024	−1025 < E < 1024	199.4	5.064
11	mag(E) < 2048	−2049 < E < 2048	398.7	10.128
12	mag(E) < 4096	−4097 < E < 4096	797.5	20.256

(1) Measurement resolution using the HP 10706A Plane Mirror Interferometer fixed at λ/128 (4.95 nanometres or 0.195 microinches).

(2) "E" is the state of the Position Error output bits (in uncompensated raw counts).

*OP0-*OP2

Description: Types of Optics Used

Type: Comand

Power-up Default: *OP1

*OP0 through *OP2 are used to inform the axis board which type of optics are installed, so that it may select the correct I/O unit conversion constants.

- *OP0 is used with Linear and Single Beam optics, resulting in λ/64 resolution.
- *OP1 is used with Plane Mirror optics, resulting in λ/128 resolution.
- *OP2 is used with HP 10716A High Resolution Inteferometer, resulting in λ/256.

*POS

Description: Position Output Variable

Type: Read-only Floating Point Data

*POS is the position output variable representing position only, not position error as do the hardware Position Error signals. *POS is obtained from the position counter as follows:

*POS = (position counter value) × (*TCN) × (units conversion constant)

except in the *RAW units mode, where *POS represents the raw position counter value. *POS is in the following units in different unit modes:

*Table 4D-8. *POS I/O Data Units*

Units Mode	*POS I/O Data Units
*ENG	compensated inches
*MET	compensated millimetres
*LAM	compensated counts ($\lambda/64$ or $\lambda/128$, where λ equals the vacuum wavelength)
*RAW	Uncompensated counts ($\lambda/64$ or $\lambda/128$, where λ equals actual wavelength)

*PRE

Description: Position Counter Preset

Type: Command

*PRE presets the position counter to the value currently in the destination register. The lowest five bits of the position counter are not affected by the *PRE command, thereby placing a limit on the degree of accuracy to which the counter may be set. The five lowest bits represent a preset resolution of 32 counts ($\lambda/2$, or $\lambda/4$, with optics type *OP0, or *OP1, respectively).

To preset the counter to a specific position, load that position into the destination register and execute the *PRE command. The destination register contents will be copied into the position counter.

*RAW

Description: Uncompensated Raw Counts

Type: Command

This command sets the I/O units for an axis to uncompensated raw counts. Each count represents $\lambda/64$ or $\lambda/128$ (depends on optics). The value of λ is the wavelength in the current environment. Each axis may have different I/O units. (see *ENG, *LAM, *MET)

Because there is no compensation in the *RAW units mode, the software position update and destination input rates are higher than in the other I/O modes. Also, periodic update of *TCN is unnecessary.

***REV**

Description: Axis Board's Software Revision Date

Type: Read-only Integer Data

The *REV data mnemonic returns the axis board's software revision date in the following format:

<space>DDDD

where DDDD is the HP standard four-digit date code (e.g., 2432 represents week 32 of 1984).

***SMG**

Description: Signed-Magnitude Format

Type: Command

*SMG changes the hardware Position Error output lines to sign magnitude format. (Also see *TCP — two's-complement format).

***STA**

Description: Axis Board's Status Byte

Type: Read-only Integer Data

*STA is the board status byte and is normally zero. Nonzero values of *STA indicate various error conditions (*Table 4D-9*).

*STA is reset with the HP 5507A front panel (soft) reset button, or with the equivalent ERST command.

Table 4D-9. Status Byte-Defined Errors

*STA value	Condition
0	No errors; normal
40	Measurement Signal Absent
41	Measurement Loss of Lock
42	Maximum Slew Rate Exceeded
43	Position Counter Overflow
44	Destination Entry Out Of Range
45	Clip Limit Entry Out Of Range
46	Null Limit Out Of Range
47	Compensation Entry Out Of Range
48	PLL Frequency Test Entry Out of Range
49	System Error
254	Card Self-Test Failure

***TCN**

Description: Total Compensation Number

Type: Read/Write Floating Point Data

Range: 0.99 to 1.01 Power-up Default: 1.00

*TCN is the wavelength-of-light and material temperature compensation number used internally to multiply raw counts to obtain compensated position information for *POS. It is also used to divide *DES input information prior to storage in the subtractor's destination register, thus compensating stage destination for wavelength and material temperature effects.

***TCP**

Description: Two's Complement Format

Type: Command

*TCP changes the Position Error output lines to two's-complement format (powers up default). Also see *SMG — sign magnitude format.

***TST**

Description: Special Test Mnemonic

Type: Read/Write Floating Point Data

Range: –0.24 to +0.24, 0.76 to 2.24 Power-up Default: 0.00

*TST is a special test mnemonic which switches the axis measurement input between the normal measurement inputs (selected by *MIN and *MEX), and three fixed test frequencies of 1.0 MHz, 1.5 MHz, and 2.0 MHz. Values sent to *TST are rounded to the closest test frequency value. Sending a *TST value of zero switches the measurement back to the last input selected by a *MIN or *MEX command (the position counter is also zeroed). These test frequencies are useful for testing software without connecting a receiver or laser head (see also IREF).

***ZRO**

Description: Position Counter Reset

Type: Command

*ZRO resets the position counter to zero.

Axis Board Reset Response

HARD RESET

The variables and mode conditions listed in *Table 4D-10* are set when the system is forced into the "hard reset" cycle. The user may initialize hard reset by either:

- Power-cycling the HP 5507A Laser Transducer (i.e., cycling the ac power switch from on-to-off-to-on), or
- Sending the BOOT command to the HP-IB board
- Toggling the Internal Master Reset Switch located on the HP-IB board

Table 4D-10. Axis Board Hard Reset Defaults

Variable or Mode	Mnemonic	Reset Variable or Mode to
Status Byte	*STA	Zero
Compensation	*TCN	1.0000
I/O Units	*ENG/*MET/*LAM/*RAW	*MET
Optics Type	*OP0,*OP1, and *OP2	*OP1 (Plane mirror - λ/128)
Sampling Mode	*INT, *EXT	*INT (Internal)
Error Mode	*EM0, *EM1	*EM0 (Error Mode 0)
Measurement Input Channel	*MIN, *MEX	*MEX (HP 10780A Receiver)
Clip Level	*CLP	Zero
Null Mask	*NUL	Zero
Destination	*DES	Zero
Position Counter	*POS	Zero
Drive Enable Out–	*DRO, *DR1	*DR0 (off)
Position Error Output Format	*SMG, *TCP	*TCP (Two's complement)

SOFT RESET

The "soft reset" cycle may be initialized by performing one of the following:

- Depressing the front panel RESET key
- Sending the ERST command to the HP-IB board
- Sending the HP-IB device independent commands Device Clear (DCL) or Selected Device Clear (SDC)

The "soft reset" performs the following on any axis with an error:

- Status byte (*STA) reset to zero
- Position counter reset to zero
- Measurement error reset
- Programming error reset

Only axes with an error will be reset. All other axes remain the same.

Error Messages

The error messages, combined with the front panel annunciators (LEDs), provide assistance with both system programming and hardware problems. LED indications and sequences are covered briefly on page 4B-25.

ERROR INDICATIONS

The SYSTEM ERROR LED remains off if the system operates properly. If an error is detected in the system — be it a hardware, programming, or data entry error — the HP 5507A's operation is not suspended. Internal software enables the user to interrogate the system via the controller as to the source of the error. The ERRM? data request returns an ASCII data item that contains the following information:

- Error source information
- Error number
- Short description of the error

After eliminating the cause of the error, the error message can be cleared by initiating a system "soft reset".

AXIS BOARD ERROR MESSAGES

-102 Card Self-test Failure

Axis board hardware errors found during the power-up self tests produce this error.

-101 System Error

The axis board produces this error when an undefined command from the HP-IB board is received. This error signifies an internal system fault and should not occur during normal operation. If the BOOT command does not clear up the error, there is a backplane communication hardware problem on either the HP-IB board, or more likely, the axis board.

440 Measurement Signal Absent

This error indicates that there was no measurement signal present when the last "soft Reset" was received.

441 Measurement Loss of Lock

This error is sourced when a glitch or dropout affects the axis measurement input. The measurement data will be invalid when this occurs.

442 Maximum Slew Rate Exceeded

This error indicates that the measurement slew rate has exceeded permissible limits, resulting in invalid measurement data.

443 Position Counter Overflow

The optics have traveled beyond the range of the electronics.

444 Destination Entry Out of Range

The destination data sent to the axis board is outside of the permissible range for the programmed combination of optics type and readout units. Although the illegal destination may be read back from the axis, it will not have modified the actual internal measurement destination register, which can be read after a "soft reset" clears the error.

445 Clip Limit Entry Out of Range

The clip limit specifier sent to the axis is not within the permissible range of 0 or 8-20. The illegal clip limit value may be read back from the axis prior to any "soft resets", however, the actual clip limit is not changed until a valid value is sent.

446 Null Limit Entry Out of Range

The Position Null limit specifier sent to the axis is not within the permissible range of 0-12. The illegal null limit value may be read back from the axis prior to a "soft reset", however, the actual null range is not changed until a valid value is sent.

447 Compensation Entry Out of Range

An attempt was made to load a compensation number outside of the permissible range (0.99 - 1.01). The illegal compensation number may be read back from the axis board prior to a "soft reset", but the actual value used for compensation will not be changed until a valid number is sent.

448 PLL Frequency Test Entry Out of Range

An attempt was made to load an illegal value into the measurement error detection phase locked loop test frequency specifier, *TST.

Table 4D-11. Axis Board Error Message Summary

Error	Description	Status Byte
-102	Card Self-test Failure	254
-101	System Error	49
440	Measurement Signal Absent	40
441	Measurement Loss of Lock	41
442	Maximum Slew Rate Exceeded	42
443	Position Counter Overflow	43
444	Destination Entry Out of Range	44
445	Clip Limit Entry Out of Range	45
446	Null Limit Out of Range	46
447	Compensation Entry Out of Range	47
448	PLL Test Entry Out of Range	48

SECTION IV
SUBSECTION E

CONTENTS

SECTION IV

SUBSECTION E
HP 10934A A-QUAD-B AXIS BOARD

HP 10934A A-QUAD-B AXIS BOARD DESCRIPTION

The HP 10934A Axis Board has three main functions. First, it monitors the measurement and reference signals to keep track of position. Second, it uses this position information and software programmable output functions to generate A-Quad-B or Up/Down Pulse output signals. These output signals can be programmed to include both automatic compensation and geometric correction factors. Third, it provides multiple data-communications pathways to the HP 5507A/B backplane via two RS-232C serial ports, and one 8-bit parallel port.

The 8-bit parallel interface can be connected to an HP 9000 Series 200/300 Computer's GPIO interface (see Section III). It has access to all boards in an HP 5507A/B. In addition, the RS-232C serial ports and 8- bit parallel port can be used to communicate information directly to/from a machine-tool controller or other compatible data-communications device.

NOTE

Throughout this section the asterisk (*) preceding a mnemonic must be replaced by the backplane address letter (S through Z) corresponding to the board being programmed.

Address

The A-Quad-B Axis Board may be assigned to backplane address S, T, U, V, W, X, Y, or Z by setting the Backplane Address switches of the DIP switch located on the upper-left corner of the board (*Figure 4E-1*). Proper operation requires assignment of a unique address to each A-Quad-B Axis Board (see *Table 4A-1* and "HP 5507A/B Backplane Basics" in Section III).

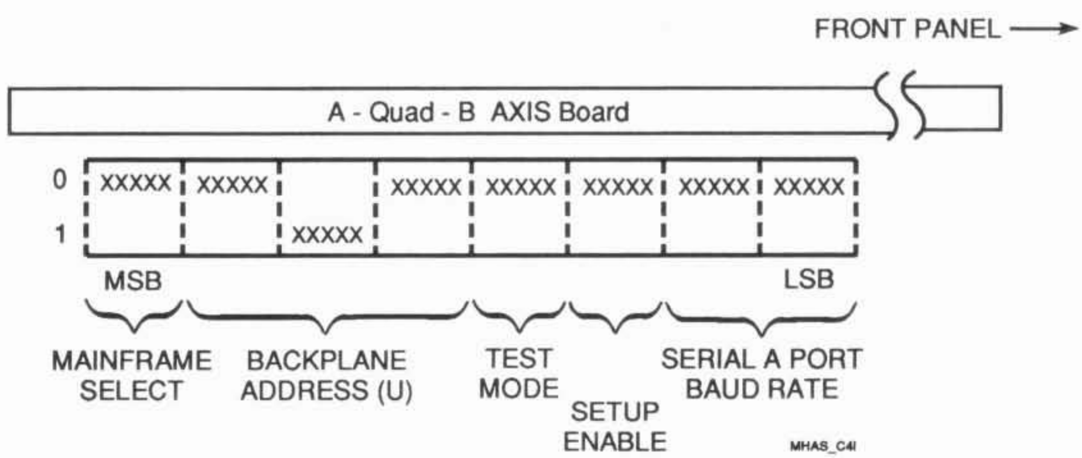


Figure 4E-1. HP 10934A Address Switches

A-QUAD-B AXIS BOARD SETUP

The HP 10934A is designed for stand-alone operation after the initial setup process has been completed. The general procedure for this setup process is as follows:

a. Install all boards into the HP 5507A/B and connect it to the computer being used for setup using either the HP-IB, the Serial, or the 8-bit Parallel port.

b. Set all SETUP ENABLE switches to the ENABLE position (1) and turn on (or hard reset) the HP 5507A/B.

c. Send the values for all setup parameters to all A-Quad-B Axis boards (use the supplied software or other program that sends these values to the desired boards).

d. Send a *SAV command to each A-Quad-B Axis board.

e. Move all the SETUP ENABLE switches to the DISABLE position (0).

All HP 10934A boards will now power up with the desired configuration, eliminating the need for a computer to be connected to the HP 5507A/B (some applications may still desire this connection to monitor the laser measurement system, however hardware lines do provide access to all required status and control functions).

Table 4E-1 presents a brief mnemonics setup summary, and the following pages describe each category in detail. One option from each of those categories must be selected to properly setup the A-Quad-B Axis Board. Information on specific mnemonics can be found in the Reference Section (pages 4E-16 through 4E-39).

The setup enable switch must be in the "enable" position (1) to change most of the setup parameters. Once selected, these values can be saved in EEPROM with the *SAV command. Moving the setup enable switch to the "disable" position (0) "locks" the setup parameters. The board will then power-up with the saved setup information. (See the "Setup Enable" paragraphs in Section III for additional details.)

Software Setup Program

The program on the included disc may be used to assist with the setup operation. It will run on any MS-DOS® compatible system (3.3 or higher) equipped with at least 1 MB of memory, running MS Windows® 3.0 and an RS-232C Serial data communications port. See the README file on this disc for details on the program's operation.

The general operating commands are covered in "Software Interface", while more involved capabilities of the HP 10934A are discussed in subsequent paragraphs.

Table 4E-1. A-Quad-B Laser Axis Board Setup Summary

FACTORY SETTING	OPTIONS	DESCRIPTION
*OPT0	*OPT1, *OPT2	Selects Optics Type: 0 - Linear or Single Beam 1 - Plane Mirror 2 - High Resolution
*DIR0	*DIR1	Selects Direction Sense: Set so *POS value increases as reflector moves away from interferometer.
*MEX	*MIN	Selects Measurement Input: *MEX - HP 10780 Receiver *MIN - HP 5518A
*PUN0	*PUN1	Selects Pulse/IO Units: *PUN0 - mm *PUN1 - inches
*RES0.00001	*RES x	Specifies Output Pulse Resolution: (use minus values to swap A and B output lines)
*KHZ781	*KHZ n	Selects Output Pulse Rate.
*QAD0	*QAD1	Selects Output Pulse Type: *QAD0 - UP/DOWN Pulses *QAD1 - A-Quad-B Signals
*BCN0.999728766	*BCN x	Specifies Starting Compensation Number.
*COF0	*COF x	Specifies Compensation Offset.
*CUR0	*CUR n	Selects Compensation Mode/Rate: see *CUR in Mnemonics Reference.
undefined	*CMP0;*WCM n;n	Specifies Compensation Mnemonic: see Using Compensation Section
undefined	*CMP1;*WCM n;n;*CMD x	Specifies Compensation Limit Mnemonic: see Using Compensation Section.
undefined	*CMP2;*WCM n;n	Specifies Initial Comppensation Mnemonic: see Using Compensation Section.
undefined	*CMP3;*WCM n;n;*CMD x	Specifies Filter Time Constant: see Using Compensation Section
undefined	*CMP4;*WCM n;n;*CMD x	Specifies Coefficient of Thermal Expansion: see Using Compensation Section.
*PRD0	*PRD x	Specifies Preset Distance.
*DPD0	*DPD x	Specifies Deadpath Distance.
*MPO0.1	*MPO x	Specifies Maximum Position Offset.
*EMD0	*EMD n	Selects Error Mode: Pulse Outputs disabled by: 0 - Measurement Errors on this Axis 1 - Any errors on this axis 2 - Measurement Errors on any Axis 3 - Any errors on Any Board
*MUR0	*MUR n	Selects *MUL Update Rate/Mode: see *MUR in Mnemonics Reference.
*PUR100	*PUR n	Selects *POS Update Rate/Mode: see *PUR in Mnemonics Reference.
*MEN0	*MEN1	Enables (1)/Disables (0) External Multiplier Samples.
*PEN0	*PEN1	Enables (1)/Disables (0) External Position Samples.
*SAM24, *SBM24	*SAM n, *SBM n	Selects Serial Ports' Mode: see *SAM/*SBM in Mnemonics Ref.
*SAR2400, *SBR2400	*SAR n, *SBR n	Selects Serial Ports' Baud Rate: see *SAR/*SBR in Mnemonics Ref.
(n = integer value, x = floating point value)		