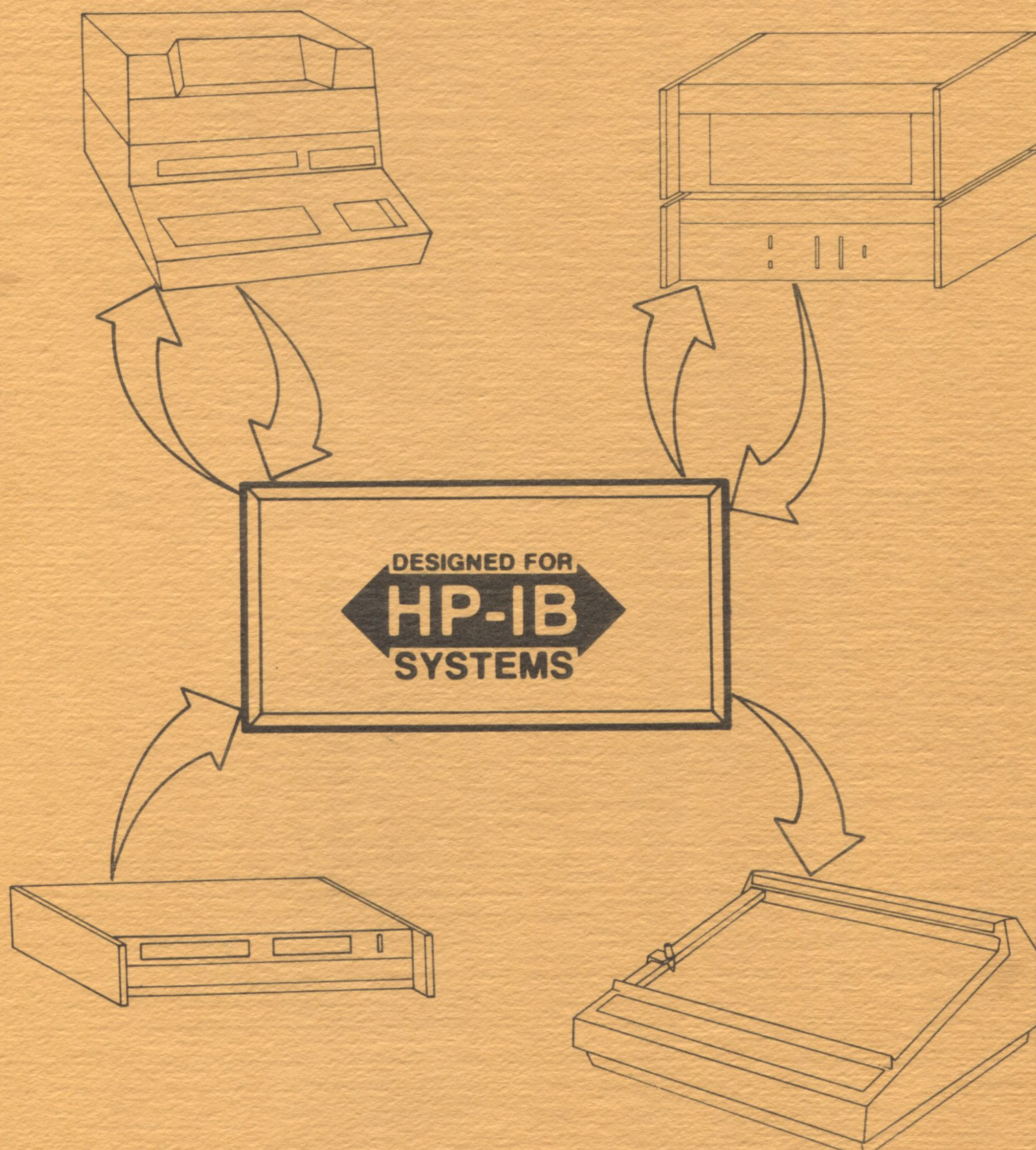
CONDENSED DESCRIPTION OF THE HEWLETT-PACKARD INTERFACE BUS



HEWLETT PACKARD

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This document is a description of the Hewlett-Packard Interface Bus (HP-IB) provided as an aid to understanding its operation.

WARNING

To help minimize the possibility of electrical fire or shock hazards, do not expose this instrument to rain or excessive moisture.

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GENERAL BUS DESCRIPTION.

The Hewlett-Packard Interface Bus (HP-IB) is a carefully defined instrumentation interface which simplifies the integration of instruments, calculators, and computers into systems. It minimizes compatibility problems between devices and has sufficient flexibility to accommodate future products. The Hewlett-Packard Interface Bus has been formally proposed to the International Electrotechnical Commission (I.E.C.), as an international standard, and to the Institute of Electrical and Electronic Engineers (I.E.E.E.) as an American standard.

The HP-IB employs a 16 line Bus to interconnect up to 15 instruments. This Bus is normally the sole communication link between the interconnected units. Each instrument on the Bus is connected in parallel to the 16 lines of the Bus. Eight of the lines are used to transmit data and the remaining eight are used for communication timing (Handshake), and control.

Data is transmitted on the eight HP-IB data lines as a series of eight-bit characters referred to as "bytes". Normally, a seven-bit ASCII (American Standard Code for Information Interchange) code is used with the eighth bit available for a parity check, if desired. Data is transferred by means of an interlocked "handshake" technique. This sequence permits asynchronous communication over a wide range of data rates.

Communication between devices on the HP-IB employs the three basic functional elements listed below. Every device on the Bus must be able to perform at least one of these functions:

a. LISTENER – A device capable of receiving data from other instruments. Examples of this type of device are: printers, display devices, programmable power supplies, programmable signal sources and the like.

b. TALKER – A device capable of transmitting data to other instruments. Examples of this type of device are: tape readers, voltmeters that are outputting data, counters that are outputting data, and so on.

c. CONTROLLER – A device capable of managing communications over the HP-IB such as addressing and sending commands. A calculator or computer with an appropriate I/O interface is an example of this type of device.

An HP-IB system allows only one device at a time to be an active talker. Up to 14 devices may simultaneously be listeners. Only one device at a time may be an active controller.

BUS STRUCTURE.

The HP-IB interface connections and Bus structure are shown in Figure 1.

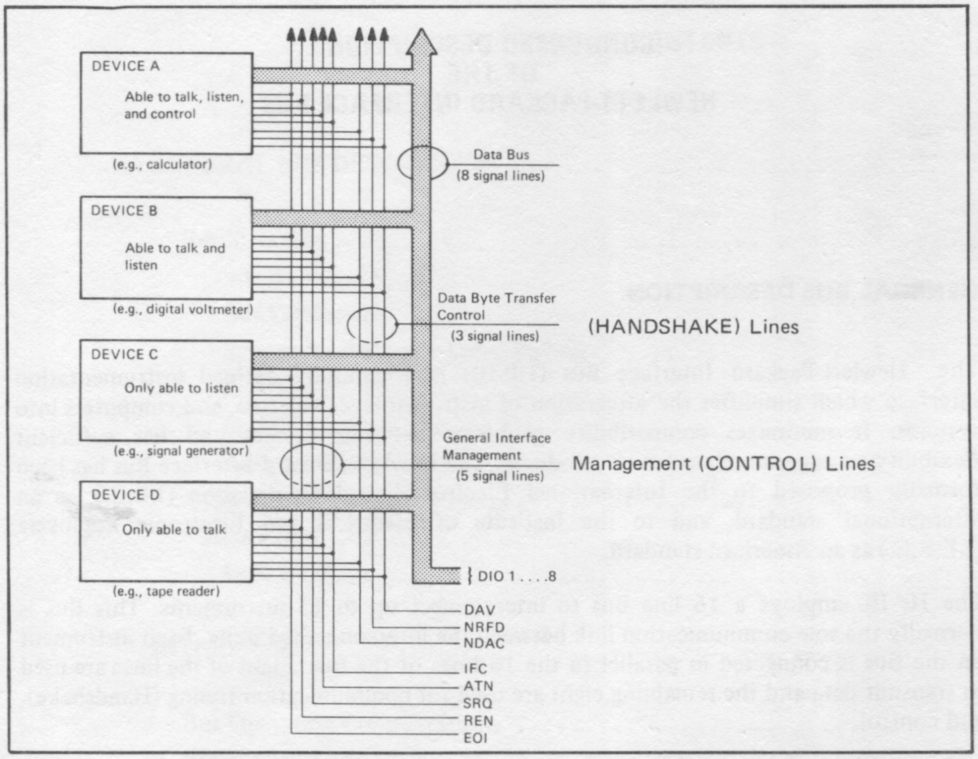


Figure 1. Interface Connections and Bus Structure.

Management (CONTROL) Lines.

The active controller manages all Bus communications. The state of the ATN (attention) line, determined by the controller, defines how data on the eight data (DIO) lines will be interpreted by the other devices on the Bus. When ATN is low (true), the HP-IB is in Command Mode. In Command Mode the controller is active and all other devices are waiting for instructions. Command Mode instructions which can be issued by the Controller in "Command Mode" include:

a. Talker Address –

A seven bit code transmitted on the HP-IB which enables a specific device to talk. Only one Bus device at a time may act as the talker. When the controller addresses a unit to talk the previous talker is automatically unaddressed and ceases to be a talker. Confusion would result if more than one device were allowed to talk at a time.

b. Listener Address –

A seven-bit code transmitted on the HP-IB which enables a specific device to listen. Several Bus devices at a time (up to 14) may be listeners.

c. Universal Commands –

Bus devices capable of responding to these commands from the controller will do so at any time regardless of whether they are addressed. These commands will be covered in more detail later.

d. Addressed Commands –

These commands are similar to universal commands except that they are recognized only by devices that are addressed as listeners.

e. Unaddress Commands –

1. "Unlisten" Address Command –

This command unaddresses all listeners that have been previously addressed to listen.

2. "Untalk" Address Command –

This command unaddresses any talker that had been previously addressed to talk.

Bus Commands.

In "Command Mode" one or more special codes known as "bus commands" may be placed on the HP-IB. These commands have the same meaning in all Bus systems. Each device is designed to respond to those commands that have a useful meaning to the device and will ignore all others. The operating manual for each device will state which Bus commands it will obey.

Bus commands fall into three categories.

1. Universal commands affect all responding devices on the Bus, whether addressed or not.

2. Addressed commands affect only responding devices which are addressed to listen. Addressed commands allow the controller to initiate a simultaneous action from a selected group of devices on the Bus.

3. Unaddress commands are obeyed by all addressable devices. These commands unaddress devices that are currently addressed.

The Bus commands are summarized in Table 1.

Service Request and Serial Polling.

Some devices that operate on the interface bus have the ability to request service from the system controller. A device may request service when it has completed a measurement, when it has detected a critical condition, or for any other reason. Service request is initiated when a device sets the HP-IB line labeled SRQ low. The controller has the option of determining when or if a service request will be serviced. The following sequence is used to respond to a service request:

a. The controller checks for the presence of a service request.

b. If a service request is present, the controller sets the serial poll mode. *The serial poll mode is initiated by the controller transmitting the Universal Command "SPE" (ASCII character "CAN" [Octal 030]) in the "Command Mode".*

c. The controller polls one of the devices that may have requested service. It then polls the next device, and so on. *Once the serial poll mode has been enabled, responding devices on the Bus are prepared to accept a serial poll. This is done by setting ATN, addressing the device as a talker, and then removing ATN. If the device has requested service, it will respond by setting DIO line 7 low. Other DIO lines may also be set low indicating the nature of the service request.*

d. For each device that has requested service, the controller takes appropriate action.

Table 1. Summary of Bus Commands.

	COMMAND	ASCII Character	OCTAL CODE	PURPOSE
UNADDRESS COMMANDS	UNL UNLISTEN	?	077	Clears Bus of all listeners.
	UNT UNTALK	—	137	Unaddresses the current talker so that no talker remains on the Bus.*
UNIVERSAL COMMANDS	LLO Local Lockout	DC1	021	Disables front panel local-reset button on responding devices.
	DCL Device Clear	DC4	024	Returns all devices capable of responding to pre-determined states, regardless of whether they are addressed or not.
	PPU Parallel Poll Unconfigure	NAK	025	Sets all devices on the HP-IB with Parallel Poll capability to a predefined condition.
	SPE Serial Poll Enable	CAN	030	Enables Serial Poll Mode on the Bus.
	SPD Serial Poll Disable	EM	031	Disables Serial Poll Mode on the Bus.
ADDRESSED COMMANDS	SDC Selective Device Clear	EOT	004	Returns addressed devices, capable of responding to pre-determined states.
	GTL Go to Local	SOH	001	Returns responding devices to local control.
	GET Group Execute Trigger	BS	010	Initiates a simultaneous pre-proprogrammed action by responding devices.
	PPC Parallel Poll Configure	ENQ	005	This command permits the DIO lines to be assigned to instruments on the Bus for the purpose of responding to a parallel poll.
	TCT Take Control	HT	011	This command is given when the active controller on the Bus transfers control to another instrument.

***NOTE**

Talkers can also be unaddressed by transmitting an unused talk address on the Bus.

e. When all devices have been polled, the controller terminates the serial poll mode by issuing the Universal Command SPD (ASCII Character "EM", [Octal 031]).

The full sequence of operations is not necessary in all cases. For example, a system may have only one device that requests service and then only for a single purpose. When the controller detects a service request, the source of the request and the appropriate action is known immediately. Thus the use of the service request and the serial poll depends entirely on the make-up of each system and the devices involved.

Table 2. Code Assignments for "Command Mode" of Operation.

(SENT AND RECEIVED WITH ATN TRUE)

b_7					0		0		0		0		1		1		1		1	
b_6					0		0		1		1		0		0		1		1	
b_5					0	MSG (1)	1	MSG	0	MSG	1	MSG	0	MSG	1	MSG	0	MSG	1	MSG
b_4 ↓	b_3 ↓	b_2 ↓	b_1 ↓	COLUMN → ROW ↓	0		1		2		3		4		5		6		7	
0	0	0	0	0	NUL		DLE		SP	↑ MLA ASSIGNED TO DEVICE ↓	0	↑ MLA ASSIGNED TO DEVICE ↓	@	↑ MTA ASSIGNED TO DEVICE ↓	P	↑ MTA ASSIGNED TO DEVICE ↓		↑ MEANING DEFINED BY PCG CODE ↓	p	↑ MEANING DEFINED BY PCG CODE ↓
0	0	0	1	1	SOH	GTL	DC1	LLO	!		1		A		Q		a		q	
0	0	1	0	2	STX		DC2		"		2		B		R		b		r	
0	0	1	1	3	ETX		DC3		#		3		C		S		c		s	
0	1	0	0	4	EOT	SDC	DC4	DCL	$		4		D		T		d		t	
0	1	0	1	5	ENQ	PPC (3)	NAK	PPU	%		5		E		U		e		u	
0	1	1	0	6	ACK		SYN		&		6		F		V		f		v	
0	1	1	1	7	BEL		ETB		'		7		G		W		g		w	
1	0	0	0	8	BS	GET	CAN	SPE	(		8		H		X		h		x	
1	0	0	1	9	HT	TCT	EM	SPD	)		9		I		Y		i		y	
1	0	1	0	10	LF		SUB		*		:		J		Z		j		z	
1	0	1	1	11	VT		ESC		+		;		K		[		k		{	
1	1	0	0	12	FF		FS		,		<		L		\		l		¦	
1	1	0	1	13	CR		GS		–		=		M		]		m		}	
1	1	1	0	14	SO		RS		.		>		N		^		n		~	
1	1	1	1	15	SI		US		/		?	UNL	O		_	UNT	oo		DEL	

(4)

ADDRESSED COMMAND GROUP (ACG) — columns 0, MSG

UNIVERSAL COMMAND GROUP (UCG) — columns 1, MSG

LISTEN ADDRESS GROUP (LAG) — columns 2, 3

TALK ADDRESS GROUP (TAG) — columns 4, 5

PRIMARY COMMAND GROUP (PCG) — columns 0 through 5

SECONDARY COMMAND GROUP (SCG) — columns 6, 7

NOTES:
(1) MSG = INTERFACE MESSAGE
(2) b_1 = DIO1 . . . b_7 = DIO7
(3) REQUIRES SECONDARY COMMAND
(4) DENSE SUBSET (COLUMN 2 THROUGH 5). ALL CHARACTERS USED IN BOTH COMMAND & DATA MODES.

Parallel Poll.

Parallel polling permits the status of up to eight devices on the HP-IB to be checked simultaneously. The operator assigns each device a data line (DIO1 thru DIO8) which the device sets low during the parallel poll routine if it requires service. More devices can be handled, if desired, by sharing the use of each DIO line.

The parallel polling function requires the controller to periodically poll the instruments connected to the Bus. The controller interrogates (polls) the instruments by sending an EOI with ATN activated. When either EOI or ATN is removed, the controller stops polling.

Code Summary.

A code assignment summary is shown in Table 2. These assignments apply only when operating in "Command Mode".

In "Data Mode" there are no specific code assignments. However, the devices communicating in this mode must agree on the meaning of the codes they use.

The set of codes labeled "Primary Command Group" are the codes commonly used to communicate on the HP-IB. The "Secondary Command Group" is used when addressing extended listeners and talkers, or enabling the Parallel Poll Mode.

Other Bus Lines.

The three remaining HP-IB lines and their functions are:

REN (Remote Enable) – The system controller sets REN low and then addresses the devices to Listen before they will operate under remote control.

IFC (Interface Clear) – Only the system controller can activate this line. When IFC is set (true) all talkers, listeners and active controllers go to their inactive states.

EOI (End or Identify) – This line is used to indicate the end of a multiple byte transfer sequence or, in conjunction with ATN, to execute a parallel polling sequence.

NOTE

Individual instruments, at power-on, can momentarily set the IFC line to a true state.

Address Codes.

Devices with the functional capability of talker normally recognize a single byte address*. A certain group of ASCII seven-bit bytes is reserved for talk addresses (refer to Table 3). The state of the eighth bit is ignored in the "Command Mode" when addresses are being transmitted. Each device has a unique talk address which can normally be modified. The Talk Address, bits one through five, are individually selected in each device to be either high or low. The selection of these bits allows changing the device talk and/or Listen address.

Devices with the functional capability of Listener normally recognize a single character address**. The seven-bit codes reserved for Listen addresses are listed in Table 3. Each device has a unique listen address which can normally be modified.

NOTE

Bits 6 and 7 determine whether the "address" is a "listen" or "talk" address (see Table 3).

*An "extended talker" is capable of recognizing a two byte talk address.

**An "extended listener" is capable of recognizing a two byte listen address.

Devices with both talk and listen addresses have these addresses assigned in pairs, eg., if the fourth address in the column of listen addresses "≠" is selected, the talk address is "C", the fourth address in the talker address column. The talk address is automatically changed whenever the listen address is changed and vice versa. Addresses are normally alterable by the use of switches or jumpers within the instrument.

Table 3. Talk and Listen Address.

Listen Addresses									Talk Addresses								
Bits								ASCII	Bits								ASCII
b_8	b_7	b_6	b_5	b_4	b_3	b_2	b_1	Character	b_8	b_7	b_6	b_5	b_4	b_3	b_2	b_1	Character
X	0	1	0	0	0	0	0	SP	X	1	0	0	0	0	0	0	@
X	0	1	0	0	0	0	1	!	X	1	0	0	0	0	0	1	A
X	0	1	0	0	0	1	0	”	X	1	0	0	0	0	1	0	B
X	0	1	0	0	0	1	1	≠	X	1	0	0	0	0	1	1	C
X	0	1	0	0	1	0	0	S	X	1	0	0	0	1	0	0	D
X	0	1	0	0	1	0	1	%	X	1	0	0	0	1	0	1	E
X	0	1	0	0	1	1	0	&	X	1	0	0	0	1	1	0	F
X	0	1	0	0	1	1	1	’	X	1	0	0	0	1	1	1	G
X	0	1	0	1	0	0	0	(	X	1	0	0	1	0	0	0	H
X	0	1	0	1	0	0	1	)	X	1	0	0	1	0	0	1	I
X	0	1	0	1	0	1	0	*	X	1	0	0	1	0	1	0	J
X	0	1	0	1	0	1	1	+	X	1	0	0	1	0	1	1	K
X	0	1	0	1	1	0	0	’	X	1	0	0	1	1	0	0	L
X	0	1	0	1	1	0	1	—	X	1	0	0	1	1	0	1	M
X	0	1	0	1	1	1	0	.	X	1	0	0	1	1	1	0	N
X	0	1	0	1	1	1	1	/	X	1	0	0	1	1	1	1	O
X	0	1	1	0	0	0	0	0	X	1	0	1	0	0	0	0	P
X	0	1	1	0	0	0	1	1	X	1	0	1	0	0	0	1	Q
X	0	1	1	0	0	1	0	2	X	1	0	1	0	0	1	0	R
X	0	1	1	0	0	1	1	3	X	1	0	1	0	0	1	1	S
X	0	1	1	0	1	0	0	4	X	1	0	1	0	1	0	0	T
X	0	1	1	0	1	0	1	5	X	1	0	1	0	1	0	1	U
X	0	1	1	0	1	1	0	6	X	1	0	1	0	1	1	0	V
X	0	1	1	0	1	1	1	7	X	1	0	1	0	1	1	1	W
X	0	1	1	1	0	0	0	8	X	1	0	1	1	0	0	0	X
X	0	1	1	1	0	0	1	9	X	1	0	1	1	0	0	1	Y
X	0	1	1	1	0	1	0	:	X	1	0	1	1	0	1	0	Z
X	0	1	1	1	0	1	1	;	X	1	0	1	1	0	1	1	[
X	0	1	1	1	1	0	0	<	X	1	0	1	1	1	0	0	\
X	0	1	1	1	1	0	1	=	X	1	0	1	1	1	0	1	]
X	0	1	1	1	1	1	0	>	X	1	0	1	1	1	1	0	⌒

X = don't care

Handshake Lines.

Each character byte transferred on the HP-IB data lines employs the three-wire handshake sequence. This sequence has the following characteristics:

1. Data transfer is asynchronous – Data can be transferred at any rate suitable for the devices operating on the Bus. (Data rates up to 500 kilobytes per second are typical; with a maximum of 1 megabyte per second).

2. Devices with different input/output speeds can be interconnected. Data transfer rate automatically adjusts to slowest active device.

3. More than one device can accept data at the same time.

The following definitions are used throughout the remaining text.

Source – A device transmitting information on the Bus in either the Command or Data Mode.
Talker – An "addressed" source in the Data Mode only.
Acceptor – A device receiving information on the Bus in either the Command or Data Mode.
Listener – An "addressed" acceptor in the Data Mode only.

The Data Transfer or "HANDSHAKE" lines are shown in Figure 1. The mnemonics of each line have the following meanings:

DAV – Data Valid
NRFD – Not Ready for Data
NDAC – Not Data Accepted

The handshake timing sequence is illustrated in Figure 2.

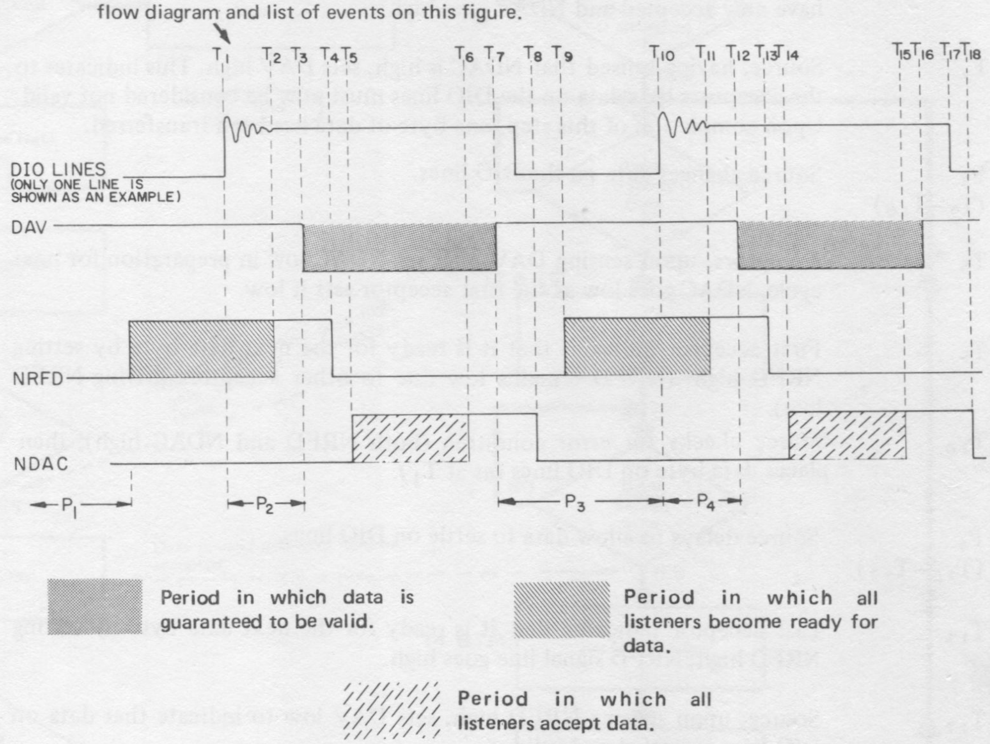
Each data byte transferred by the interface system uses the handshake process when exchanging data between source and acceptor. The handshake timing sequence is illustrated in Figure 2. In Data Mode, the source is a Talker and the acceptor is a Listener.

The timing diagram illustrates the handshake process by indicating the actual waveforms on the DAV, NRFD, and NDAC lines. The NRFD and NDAC signals each represent composite waveforms resulting from two or more Listeners accepting the same data byte at slightly different times. This is usually due to variations in the transmission path length and individual instrument response rates (delays).

The flow chart represents the same sequence of events in a different form.

The subscripted letters on the flow chart and the timing diagram refer to the same event on the list of events.

HANDSHAKE line timing diagram for one talker and multiple listeners using the handshake process. Two cycles of the handshake sequence are shown. Also refer to the flow diagram and list of events on this figure.



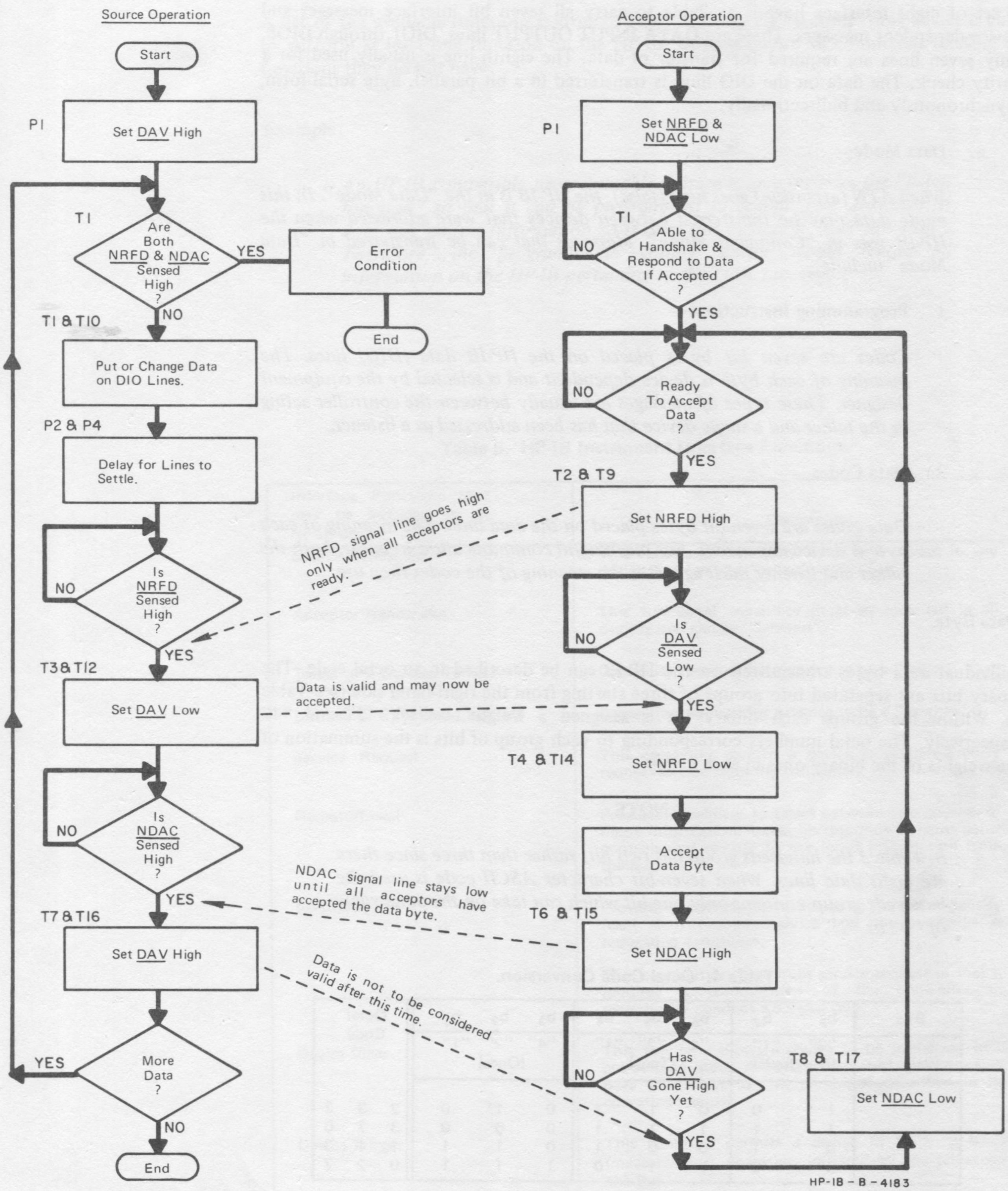
List of Events for Handshake Process

—	Source initializes DAV to high (False - data not valid).
P_1	
—	Acceptors initialize NRFD to low (True - none are ready for data), and set NDAC to low (True - none have accepted the data).
T_1	Source checks for error condition (both NRFD and NDAC high), then places data byte on DIO lines.
P_2	Source delays to allow data to settle on DIO lines.

Figure 2. Handshake Timing Sequence.

T_2	Acceptors have all indicated readiness to accept first data byte; NRFD goes high.
T_3	When the data is settled and valid, and the source has sensed NRFD high, DAV is set low.
T_4	First acceptor sets NRFD low to indicate that it is no longer ready, then accepts the data. Other acceptors follow at their own rates.
T_5	First acceptor sets NDAC high to indicate that it has accepted the data. (NDAC remains low due to other acceptors driving NDAC low).
T_6	Last acceptor sets NDAC high to indicate that it has accepted the data; all have now accepted and NDAC goes high.
T_7	Source, having sensed that NDAC is high, sets DAV high. This indicates to the acceptors that data on the DIO lines must now be considered not valid. Upon completion of this step, one byte of data has been transferred.
P_3 (T_7–T_{10})	Source changes data on the DIO lines.
T_8 *	Acceptors, upon sensing DAV high set NDAC low in preparation for next cycle. NDAC goes low as the first acceptor sets it low.
T_9	First acceptor indicates that it is ready for the next data byte by setting NRFD high. (NRFD remains low due to other acceptors driving NRFD low).
T_{10}	Source checks for error condition (both NRFD and NDAC high), then places data byte on DIO lines (as at T_1).
P_4 (T_{10}–T_{12})	Source delays to allow data to settle on DIO lines.
T_{11}	Last acceptor indicates that it is ready for the next data byte by setting NRFD high; NRFD signal line goes high.
T_{12}	Source, upon sensing NRFD high, sets DAV low to indicate that data on DIO lines is settled and valid.
T_{13}	First acceptor sets NRFD low to indicate that it is no longer ready, then accepts the data.
T_{14}	First acceptor sets NDAC high to indicate that it has accepted the data.
T_{15}	Last acceptor sets NDAC high to indicate that it has accepted the data (as at T_6).
T_{16}	Source, having sensed that NDAC is high, sets DAV high (as at T_7).
T_{17}	Source removes data byte from DIO signal lines after setting DAV high.
T_{18} *	Acceptors, upon sensing DAV high, set NDAC low in preparation for next cycle.
	* Note that all three handshake lines return to their initialized states, as at T_1 and T_2.

Figure 2. Handshake Timing Sequence (cont'd).



Logical flow of events for Source and Acceptor when transferring data using the handshake process. See list of events on next page.

Figure 2. Handshake Timing Sequence (cont'd).

Data Lines.

A set of eight interface lines is available to carry all seven bit interface messages and device dependent messages. These are DATA INPUT OUTPUT lines, DIO1 through DIO8. Only seven lines are required for transfer of data. The eighth line is usually used for a parity check. The data on the DIO lines is transferred in a bit parallel, byte serial form, asynchronously and bidirectionally.

a. Data Mode –

When ATN (attention) goes high (false), the HP-IB is in the "Data Mode". In this mode data may be transferred between devices that were addressed when the HP-IB was in "Command Mode". Messages that can be transferred in "Data Mode" include:

1. Programming Instructions –

   Codes are seven bit bytes placed on the HP-IB data (DIO) lines. The meaning of each byte is device dependent and is selected by the equipment designer. These types of messages are usually between the controller acting as the talker and a single device that has been addressed as a listener.

2. Data Codes –

   Data codes are seven-bit bytes placed on the data lines. The meaning of each byte is device dependent. For meaningful communication to occur, both the talker and listener must agree on the meaning of the codes they use.

Data Byte.

Individual data bytes transmitted on the HP-IB can be described in an octal code. The binary bits are separated into groups of three starting from the right-hand side (see Table 3). Within the groups each binary bit is assigned a weight – "1", "2" and "4" respectively. The octal numbers corresponding to each group of bits is the summation of the weights of the binary ones in each group.

NOTE

In Table 3 the hundreds group has two bits rather than three since there are eight data lines. When seven-bit character ASCII code is used the hundreds group contains only one bit which can take on the octal value of "0" or "1".

Table 4. Octal Code Conversion.

Bits	b_8	b_7	b_6	b_5	b_4	b_3	b_2	b_1	Octal Code		
Weights	"2" (Hundreds)	"1"	"4" (Tens)	"2"	"1"	"4" (Ones)	"2"	"1"			
	1	0	0	1	1	0	1	0	2	3	2
	1	1	1	1	1	0	0	0	3	7	0
	0	1	0	0	1	0	1	1	1	1	3
	0	0	0	1	0	1	1	1	0	2	7

INTERFACE.

A list of the available functions is given in Table 5. Every HP-IB compatible device is able to perform at least one function on the HP-IB. Devices ignore all commands relating to functions they do not have.

Example:

> *An HP-IB compatible programmable voltage source includes the "listen function" so that it can be programmed to accept data. However, it does not output information so it does not include a "talk function". Therefore, the programmable voltage source would ignore all information on the HP-IB pertaining to the "talk function".*

Table 5. HP-IB Instrument Interface Functions.

Interface Functions that may be included in an HP-IB device.	Comments
Source Handshake	This functional capability must be included in any device that can be a "talker" on the bus.
Acceptor Handshake	This functional capability must be included in all devices that can be "listeners".
Talker or Extended Talker*	Capability required for a device to be a "talker".
Listener or Extended Listener*	Capability required for a device to be a "listener".
Service Request	This capability permits a device to asynchronously request service from the controller.
Remote/Local	Provides capability to select between two sources of input information. Local corresponds to front panel controls and remote to the input information from the bus.
Parallel Poll	Provides capability for a device to uniquely identify itself if it requires service and the controller is requesting a response. This capability differs from service request in that it requires a commitment of the controller to periodically conduct a parallel poll.
Device Clear	This function allows a device to be initialized to a pre-defined state. A device with this capability will have the effect of this command described in its operating manual.
Device Trigger	This function permits a device to have its basic (measurement) operation initiated by the talker on the Bus.
Controller	This function permits a device to send addresses, universal commands and addressed commands to other devices on the HP-IB. It may also include the ability to conduct parallel polling to determine devices requiring service.

*Extended Talker and Extended Listener provide increased address capability. Devices with this functional capability recognize addresses that are two bytes in length rather than just one byte.

3. Systems with multiple controllers –

The modes of data transfer for these systems are the same as those listed in 2. In addition a method of passing control from one controller to another is required. One controller must be designated as the system controller. The system controller is the only device that can control the HP-IB lines designated IFC (Interface Clear) and REN (Remote Enable). When the system controller sets IFC low, all I/O operations cease and all talkers, listeners and controllers are unaddressed. Control is passed to a different controller by addressing it as a talker and commanding it to "take control" (Octal code 011).

Bus Operating Considerations.

a. When a device capable of activating IFC is powered on during system operation, it may cause the active controller on the Bus to relinquish control, resulting in errors. The Controller must transmit IFC to regain active Control.

b. Prior to addressing new listeners it is recommended that all previous listeners be unaddressed using the Unlisten Command (?).

c. Only one talker can be addressed at a time. When a new talker is addressed the former talker is automatically unaddressed.

d. The maximum accumulative length of the HP-IB cable in any system must not exceed more than 2 meters of cable per device or 20 meters, whichever is less.

e. For additional programming information consult the HP-IB User Guide for the appropriate calculator.

HP-IB Connector.

Figure 3 shows the pin configuration of the HP-IB Connector.

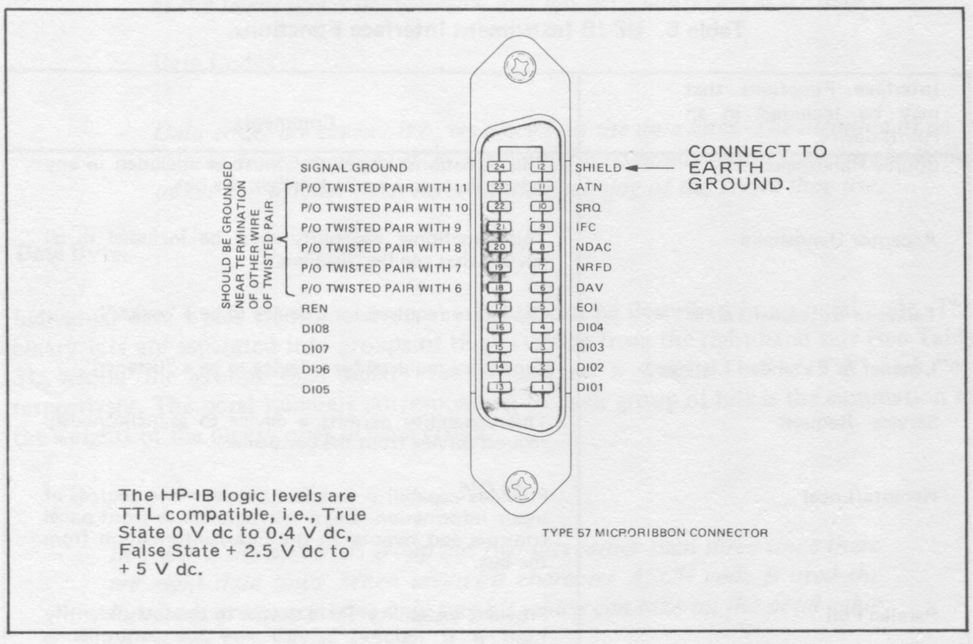


Figure 3. HP-IB Connector.

System Configurations.

HP-IB Systems can be categorized into three types:

1. Systems with no controller –

The mode of data transfer is limited to a direct transfer between one device manually set to "talk only" and one or more devices manually set to "listen only" to form a very basic fixed network system.

2. Systems with a single controller –

The modes of data transfer for these systems are:

a. Direct transfer between talkers and listeners (Data Mode).

b. Transfer from a device to a controller (Data Mode).

c. Transfer from a controller to a device (Command Mode).

GLOSSARY OF TERMS

ACCEPTOR – A device receiving information on the Bus in either the Command or Data Mode (Also, see Source).

ADDRESS – A 7-bit code applied to the HP-IB in "Command Mode" which enables instruments capable of responding to listen and/or talk on the Bus.

ADDRESSED COMMANDS – These commands allow the Bus controller to initiate simultaneous actions from addressed instruments which are capable of responding.

ATN – Mnemonic (Attention) referring to the "Command Mode" of operation on the HP-IB, or the control line which places the HP-IB in this mode.

BIT – The smallest part of an HP-IB character (Byte) which contains intelligible information.

BUS COMMANDS – A group of Special Codes which initiate certain types of operation in instruments capable of responding to these codes. Each instrument on the HP-IB is designed to respond to those codes that have useful meaning to the device and ignore all others (see Table 4).

BYTE – An HP-IB character sent over the DIO lines, normally consisting of seven-bits.

COMMAND MODE – In this mode devices on the HP-IB can be addressed or unaddressed as talkers or listeners. Bus commands are also issued in this mode.

CONTROLLER – Any device on the HP-IB which is capable of setting the ATN line and addressing instruments on the Bus as talkers and listeners. (Also see System Controller.)

DEVICE CLEAR (DCL) – ASCII character "DC4" (Octal 024) which, when sent on the HP-IB will return all devices capable of responding to pre-defined states.

DATA MODE – The HP-IB is in this mode when the control line "ATN" is high (false). In this mode data or instructions are transferred between instruments on the HP-IB.

DAV – Mnemonic referring to the control line "Data Valid" on the HP-IB. This line is used in the HP-IB "Handshake" sequence.

DIO – Mnemonic referring to the eight "Data Input/Output" lines of the HP-IB.

EOI – Mnemonic referring to the control line "End or Identify" on the HP-IB. This line is used to indicate the end of a multiple byte message on the Bus. It is also used in parallel polling.

EXTENDED LISTENER – An instrument which requires two HP-IB bytes to address it as a listener. (Also see Listener.)

EXTENDED TALKER – An instrument which requires two HP-IB bytes to address it as a listener. (Also see Talker.)

GO TO LOCAL (GTL) – ASCII character "SOH" (Octal 001) which, when sent on the HP-IB, will return devices addressed to listen and capable of responding back to local control.

GROUP EXECUTE TRIGGER (GET) – ASCII character "BS" (Octal 010) which, when sent on the HP-IB, initiates simultaneous actions by devices addressed to listen and capable of responding to this command.

HANDSHAKE – Refers to the sequence of events on the HP-IB during which each data byte is transferred between addressed devices. The conditions of the HP-IB handshake sequence are as follows:

a. NRFD, when false, indicates that a device is ready to receive data.

b. DAV, when true, indicates that data on the DIO lines is stable and available to be accepted by the receiving device.

c. NDAC, when false indicates to the transmitting device that data has been accepted by the receiver.

HP-IB – An abbreviation that refers to the "Hewlett-Packard Interface Bus".

IFC – Mnemonic referring to the Control line "Interface Clear" on the HP-IB. Only the system controller can activate this line. When IFC is set (true) all talkers and listeners on the HP-IB are unaddressed, and controllers go to the inactive state.

LISTENER – A device which has been addressed to receive data or instructions from other instruments on the HP-IB. (Also see Extended Listener.)

LOCAL LOCKOUT – ASCII character "DC1" (Octal 021) which, when sent on the HP-IB, disables the front panel controls of responding devices.

NDAC – Mnemonic referring to the control line "Data Not Accepted" on the HP-IB. This line is used in the "Handshake" sequence.

NRFD – Mnemonic referring to the control line "Not Ready For Data" on the HP-IB. This line is used in the HP-IB "Handshake" sequence.

PARALLEL POLLING – A method of simultaneously checking status on up to eight instruments on the HP-IB. Each instrument is assigned a DIO line with which to indicate whether it requested service or not.

PRIMARY COMMANDS – The group of ASCII characters which are typically used on the HP-IB (see Table 5).

REN – Mnemonic referring to the control line "Remote Enable" on the HP-IB. This line is used to enable Bus compatible instruments to respond to commands from the controller or another talker. It can be issued only by the system controller.

SECONDARY COMMANDS – The group of ASCII characters which are used to increase the address length of extended talkers and listeners to two bytes.

SELECTIVE DEVICE CLEAR – ASCII character "EOT" (Octal 004) which, when sent on the HP-IB, returns addressed devices capable of responding to a predetermined state.

SERIAL POLLING – The method of sequentially determining which device connected to the HP-IB has requested service. Only one instrument is checked at a time.

SERIAL POLL DISABLE (SPD) – ASCII character "EM" (Octal 031) which, when sent on the HP-IB, will cause the Bus to go out of serial poll mode.

SOURCE – A device transmitting information on the Bus in either the Command or Data Mode (also see Acceptor).

SRQ – Mnemonic referring to the control line "Service Request" on the HP-IB. This line is set low (true) by any instrument requesting service.

SYSTEM CONTROLLER – This is an instrument on the HP-IB which has all the features of a standard controller with the added ability to control the IFC and REN lines. (Also see Controller.)

TALKER – A device that has been addressed to transmit data on the HP-IB. (Also see Extended Talker.)

UNADDRESS COMMANDS – These commands are obeyed by all addressable devices. This category consists of the Unlisten Command (?) and the Untalk Command (–). When the Unlisten Command (?) is transmitted on the HP-IB, all devices on the Bus will be unaddressed as listeners. When the Untalk Command (–) is transmitted, all devices will be unaddressed as talkers.

UNIVERSAL COMMANDS – These commands affect every device capable of responding on the HP-IB, regardless of whether they have been addressed or not; e.g., Serial Poll Enable (SPE) and Serial Poll Disable (SPD).

UNLISTEN COMMAND – See "UNADDRESS COMMANDS".
UNTALK COMMAND – See "UNADDRESS COMMANDS".

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