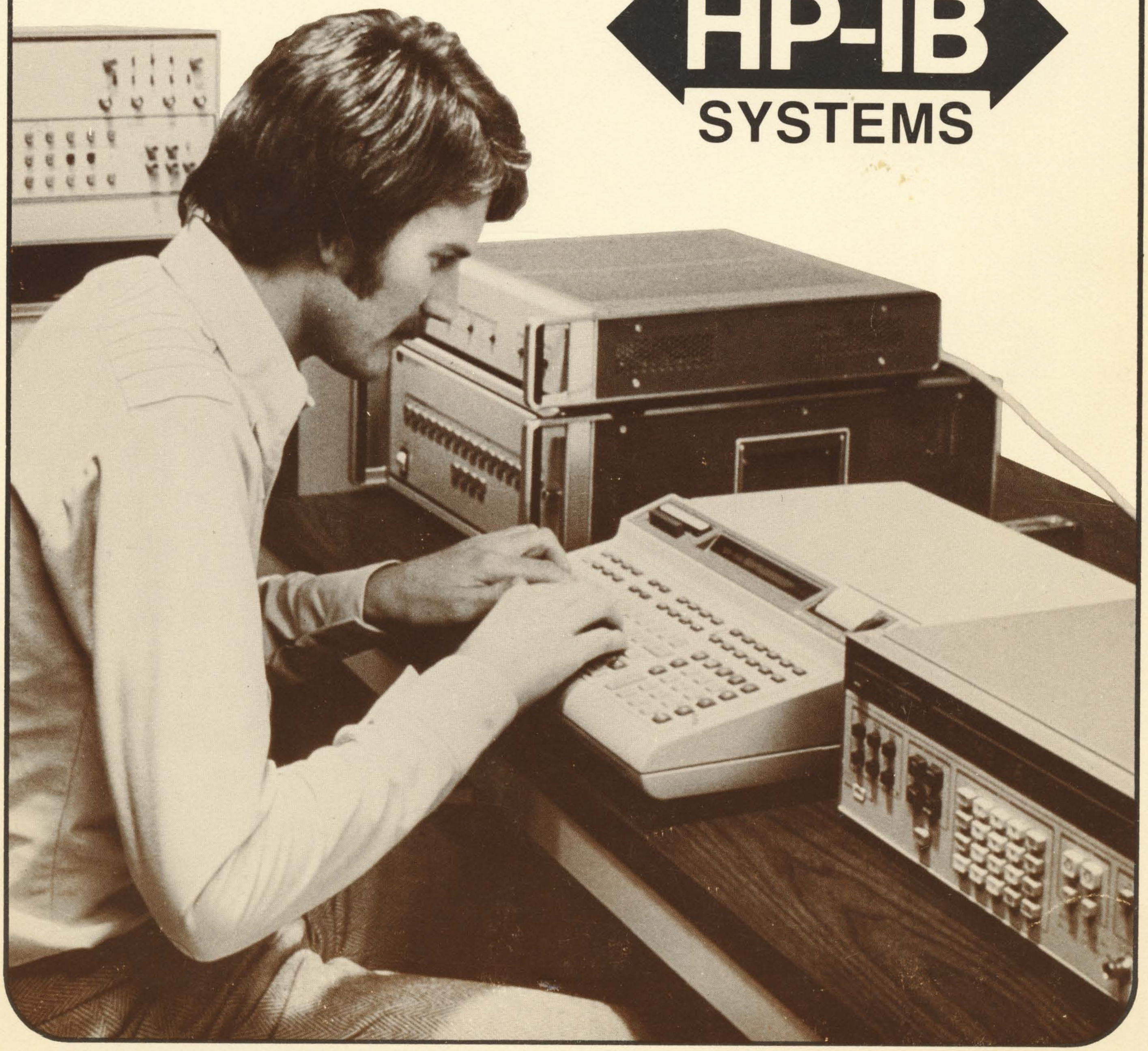
HEWLETT
PACKARD

Tutorial Description of the Hewlett-Packard Interface Bus

DESIGNED FOR
HP-IB
SYSTEMS



DESIGNED FOR
HP-IB
SYSTEMS

Not just IEEE-488, but the hardware, documentation and support that delivers the shortest path to a measurement system.

NOVEMBER 1980

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ANSI MC1.1

OVERVIEW

Tutorial Description of the Hewlett-Packard Interface Bus

Foreground

This coursebook is a tutorial description of the technical fundamentals of the Hewlett-Packard Interface Bus. It's intended to provide a thorough overview of HP-IB basics for the first-time HP-IB system designer, programmer, or user. It should be useful to instrument, computer, and system oriented engineers or technicians for either self-study, technical reference, or as an index for further research. In short, it's a broadband tutorial for learning about the Hewlett-Packard Interface Bus. A self-test is located in the rear to provide a means of measuring your performance. Let's begin with a look at what HP-IB is and where it came from . . .

Background

The Hewlett Packard Interface Bus (HP-IB) is a carefully designed and defined general purpose digital interface system and associated support which simplifies the design and integration of instruments and computers into systems. It minimizes electrical/mechanical hardware and functional compatibility problems between devices and has sufficient flexibility to accommodate a wide and growing range of future products. As such, HP-IB is an interfacing concept, and a design technique which you can take advantage of to define, design, build, and use your own measurement system for maximum cost-effectiveness. It's more than an interface, it's a design philosophy . . .

HP-IB applies to the interface of instrumentation systems in which the:

(1) Data exchanged among the interconnected apparatus is digital (as distinct from analog)

(2) Number of devices that may be interconnected by one contiguous bus does not exceed 15

(3) Total transmission path lengths over the interconnecting cables does not exceed 20 meter or 2 meter per device, whichever is less (when not using a bus-extension technique).

(4) Data rate across the interface on any signal line does not exceed 1 M byte/second.

HP-IB evolved from an internal Hewlett Packard need for a standarized instrumentation interface system. The chronology of the HP-IB evolution is summarized here:

- Sept. '65 — HP began to look at how to standardize "the interfacing of all HP future instruments."
- March '72 — U.S. Advisory Committee (IEC) formed. The committee takes HP proposal as starting point.
- Sept. '74 — IEC approves for ballot draft document (U.S. Proposal).
- April '75 — IEEE Publishes IEEE-488.
- Jan. '76 — ANSI Publishes MC1.1.
- Nov. '78 — IEEE Revises IEEE-488.
- June '80 — IEC 625-1 published.

Initial HP design efforts beginning as early as 1965 form the interface framework which was later taken by the newly-formed International Electrotechnical Commission (IEC) Technical Committee 66, Working Group 3 as a starting proposal. By September, 1974, a draft document of the HP proposal was approved for balloting by the IEC. In April, 1975, the Institute of Electrical and Electronics Engineers (IEEE) published their document IEEE-488/1975, "Digital Interface for Programmable Instrumentation," which contains the Electrical, Mechanical and Functional specifications of an American Standard interfacing system. The identical MC1.1 was published by the American National Standards Institute (ANSI) in January, 1976. A revision of the IEEE-488 occurred in Nov., 1978, primarily for editorial clarification and addendum. More recently (June, 1980), the IEC has published its version IEC 625-1: Part 1, "An Interface System for Programmable Measuring Apparatus (Byte Serial Bit Parallel)."

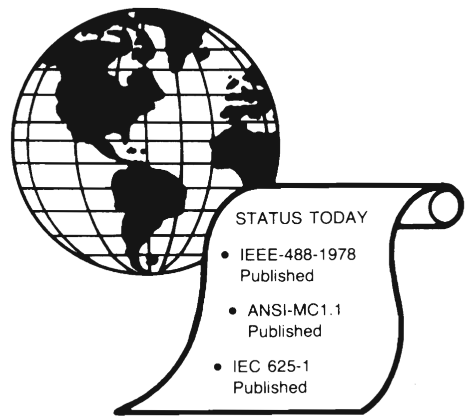
Status today

As of August, 1980, there are three major standards defining byte serial bit parallel interface systems for instrumented systems.

1) IEEE 488-1978

2) ANSI MC1.1 (Identical)

3) IEC 625-1 (Not identical)



Status of standardization efforts to date

The IEEE-488 is most widely used internationally and is implemented in several brand versions:

- HP-IB
- GPIB
- IEEE BUS
- ASCII BUS
- PLUS BUS
- IEC BUS

The IEEE-488 standard has been published in 9 languages and has been used by more than 170 manufacturers in more than 14 countries to design more than 1000 products*. In this global market the number of IEEE-488 compatible products are growing at between 30% and 50% a year. It is one of the most carefully defined, consistent, and highly used interface systems in the world. Let's pause therefore to take a look at what makes it so . . .

*Fall 1980 estimate

What comprises an interface system?

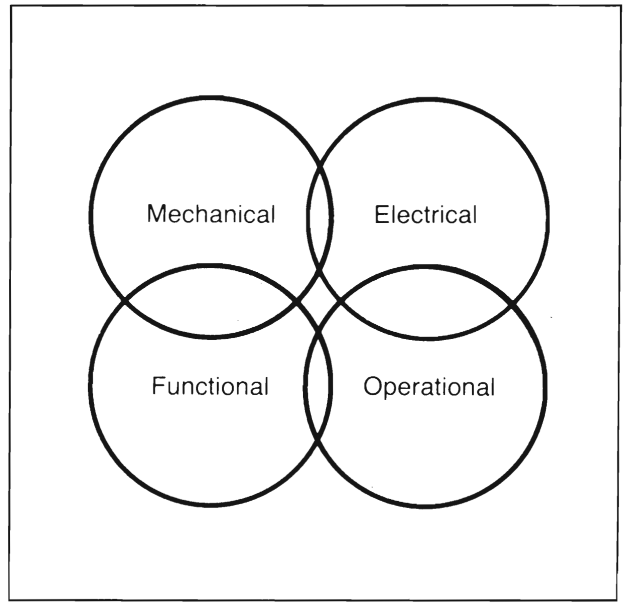
An interface system can be totally characterized in terms of the Functional, Electrical, Mechanical, and Operational specifications of the interface.

FUNCTIONAL — Total set of allowable interface functions and their logic descriptions (Application independent)

ELECTRICAL — Logic levels, protocol, timing, termination, etc. (Application independent)

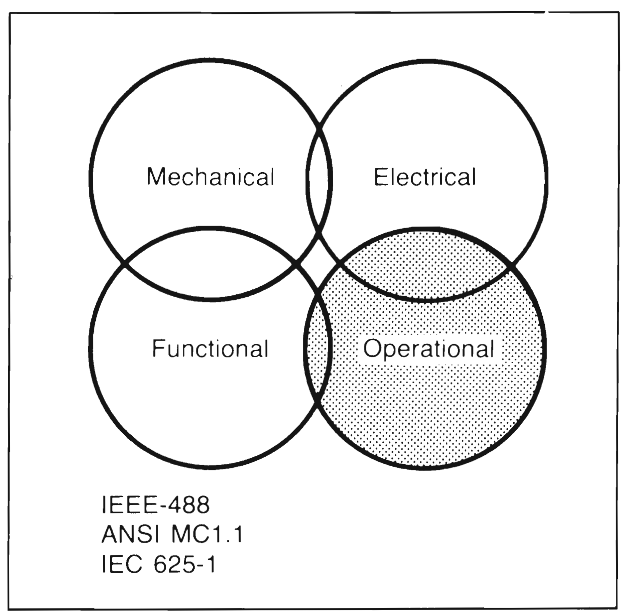
MECHANICAL — Connector, Mounting, Cable assembly, etc. (Application independent)

OPERATIONAL — Total set of allowable device functions and their logic descriptions (Applications dependent)



Defining an interface system

The IEEE-488, ANSI MC1.1, and IEC 625-1 standards address three of these areas but not the Operational area. This gives instrument and computer designers the flexibility to optimize their products to the intended applications. This includes *which* functions they choose and to some degree *how* they choose to implement them.

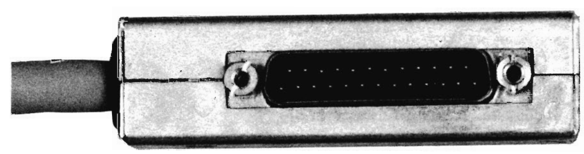


Providing design flexibility

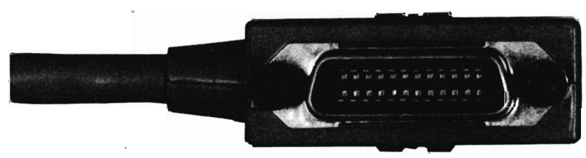
Comparing the standards

The IEEE-488 and ANSI MC1.1 are identical in all three of these characteristic areas.

The proposed IEC 625-1 differs from the others in the Mechanical area. This standard specifies a 25-pin PIN type connector rather than the 24-pin RIBBON type specified by the American Standards (Pin 25 is an extra signal return line). Unfortunately, the 25 pin connector is used extensively as part of the Electronic Industry Association (EIA) Recommended Standard RS-232-C "Interface Between Data Terminal Equipment and Data Communications Equipment Employing Serial Binary Data Interchange" for data communications. Signal lines utilizing this serial scheme employ voltage levels up to ±25V with .5 ampere short-circuit current capabilities. The down-side risks of connecting RS-232-C driver circuits to an IEC compatible device include potential damage.



IEC 625-1 ± 5V @ 48 mA
CCITT-V24 (RS-232-C) ± 25 V @ 500 mA



IEEE 488/ANSI MC1.1 ± 5V @ 48 mA

IEC vs. IEEE/ANSI connector distinction

CAUTION

Component damage, due to incompatible voltage levels, is possible if data communication and instrumentation interfaces are inadvertently interconnected (IEC 625-1 compatible device to an RS-232-C compatible interface). Any mechanical specification difference between the IEEE-488/ANSI MC1.1 and IEC 625-1 standards may be accommodated by a simple (physical) adaptor assembly when products implemented from the two standards are interconnected.

In Europe about 90% of the bus-compatible products presently prefer or offer the IEEE-488/ANSI MC1.1 connector. Many of the manufacturers offer the option of either type and there are simple adaptors on the market.

The following information will help you obtain your own copies of the interface standards just discussed.

Ordering Interface Standards

IEEE	ANSI	IEC	EIA
IEEE 488-1978	ANSI MC1.1	IEC 625-1	* EIA RS-232-C
"Digital Interface for Programmable Instrumentation"	"Digital Interface for Programmable Instrumentation"	"An Interface System for Programmable Measuring Apparatus (Byte Serial Bit Parallel)"	"Interface Between Data Terminal Equipment and Communication Equipment Employing Serial Binary Data Interchange"
IEEE STANDARDS	ANSI STANDARDS	IEC STANDARDS	EIA STANDARDS
345 E. 47th Street New York, New York 10017 Price: $9.50 (U.S.)	1430 Broadway New York, New York 10018 Price: $10.00 (U.S.)	1, rue de Varembe 1211 Geneva 20 Switzerland Price: 150 Swiss Francs	2001 Eye St. N.W. Washington, D.C. 20006 Price: $5.10 (U.S.)

*recommended companion document "Industrial Electronics Bulletin No. 9 — Application Notes for EIA Standard RS-232-C" ($2.60 in U.S.)

Further information from Hewlett Packard is described in the INTERNAL BIBLIOGRAPHY near the end of this handout.

Further information from other sources is described in the EXTERNAL BIBLIOGRAPHY near the end of this handout.

HP-IB: Going beyond the standards

The Hewlett Packard Interface Bus (HP-IB) begins by being totally consistent with all Electrical, Mechanical, and Functional specifications of the IEEE 488/ANSI MC1.1 standards. It also is totally consistent with the Electrical and Functional specifications of the IEC 625-1 standard. Hewlett Packard's experience designing HP-IB system components leads to additional "Designed for Systems" benefits in the operational area of HP-IB products/systems and in the programmer/user conveniences engineered into them. First, a technical overview of HP-IB . . .

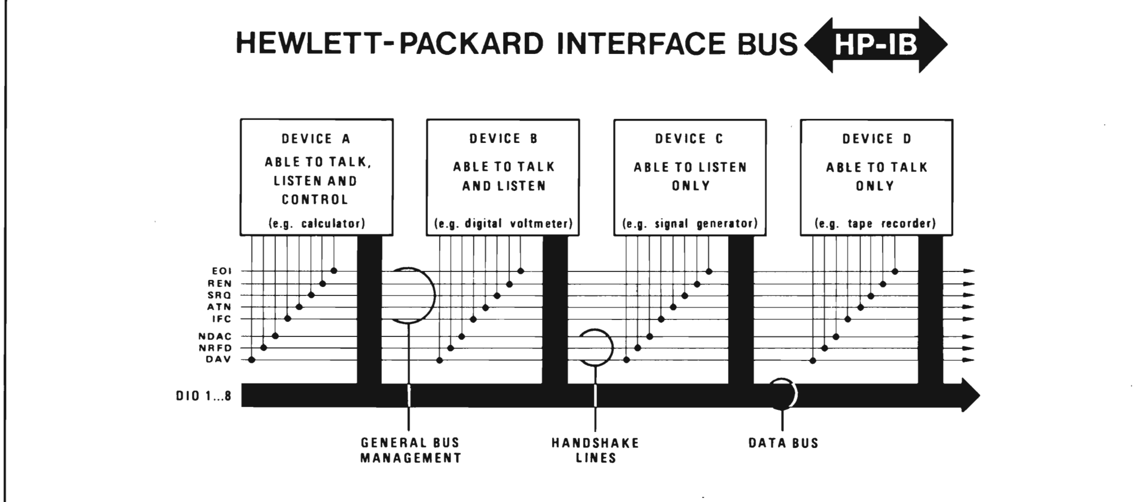
Technical overview of IEEE 488/ANSI MC1.1

The key specifications of HP-IB are summarized here:

- INTERCONNECTED DEVICES — Up to 15 maximum on one contiguous bus.
- INTERCONNECTION PATH — Star or linear bus network up to 20 meters total transmission path lengths.
- SIGNAL LINES — Sixteen active total; 8 data lines and 8 lines for interface and communication management.
- MESSAGE TRANSFER SCHEME — Byte-serial, bit-parallel, asynchronous data transfer using interlocking three-wire handshake technique.
- MAXIMUM DATA RATE — One megabyte per second over limited distances; 250 to 500 kilobytes per second typical maximum over a full transmission path. The actual data rate is determined by the devices in communication at the time.
- ADDRESS CAPABILITY — Primary addresses, 31 Talk and 31 Listen; secondary (2-byte) addresses, 961 Talk and 961 Listen. There can be a maximum of 1 Talker and up to 14 Listeners at a time.
- PASS CONTROL — In systems with more than one controller, only one can be active at a time. The currently active controller can pass control to one of the others. Only the controller designated as system controller can assume control.
- INTERFACE CIRCUITS — Driver and Receiver circuits TTL and Schottky compatible.

Functional aspects

The HP-IB interface system utilizes a party-line bus structure (devices share signal lines) to which a maximum of 15 devices may be connected in one contiguous bus. Sixteen signal lines and 8 ground lines are used to interconnect devices in a parallel arrangement and maintain an orderly flow of device and interface related information.



Structure of the HP-IB

Every HP-IB device must be capable of performing one or more of the following interface functions (roles):

a. LISTENER — A device capable of receiving data over the interface when addressed. Examples of this type of devices are: printers, display devices, programmable power supplies, programmable signal sources and the like. There can be up to 14 active listeners simultaneously on the interface.

b. TALKER — A device capable of transmitting data over the interface when addressed. Examples of this type of devices are: tape readers, voltmeters that are outputting data, counters that are outputting data, and so on. There can be only one active talker on the interface at a time.

c. CONTROLLER — A device capable of this includes specifying the talker and listeners for an information transfer (including itself). A computer with an appropriate I/O card is an example of this type of device. There can be only one active controller on the interface at a time. In multiple controller systems only one can be a SYSTEM CONTROLLER (MASTER).

INTERFACE FUNCTIONS

Interface functions are predefined capabilities which could be designed into an HP-IB device. **The designer is free to choose which are implemented in a device depending on the particular device's intended application.** The total available set is summarized here:

Available Interface Functions

Interface Functions that may be included in an HP-IB device.	Mnemonic	Comments
Talker or Extended Talker	T,TE	Capability required for a device to be a "talker".
Listener or Extended Listener	L,LE	Capability required for a device to be a "listener".
Source Handshake	SH	This provides a device with the capability to properly transfer a multiline message.
Acceptor Handshake	AH	This provides a device with the capability to guarantee proper reception of remote multiline messages.
Remote/Local	RL	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.
Service Request	SR	This capability permits a device to asynchronously request service from the controller.
Parallel Poll	PP	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	DC	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.

OVERVIEW

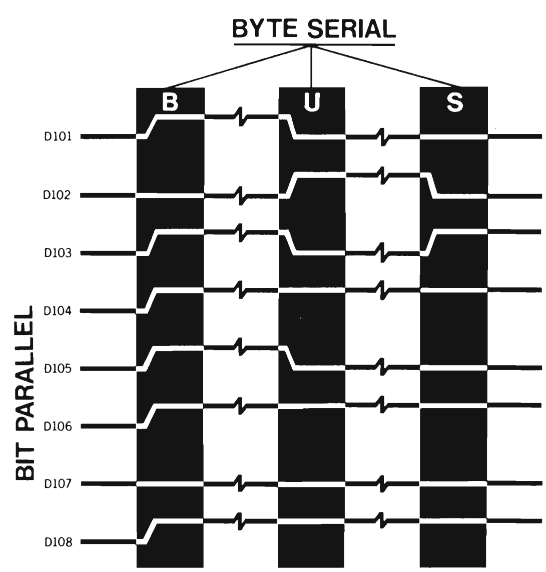
Available Interface Functions (continued)

Interface Functions that may be included in an HP-IB device.	Mnemonic	Comments
Device Trigger	DT	This function permits a device to have its basic operation initiated by the talker on the Bus.
Controller	C	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 polling to determine devices requiring service.
Drivers	E	This code describes the type of electrical drivers used in a device.

The HP-IB interface bus signal lines all use a low-true logic convention with positive polarity and are grouped into three sets:

a. DATA LINES — An 8-bit bidirectional bus is used to transfer information from device to device on the interface. Normally, a 7-bit ASCII (American Standard Code for Information Interchange) code is used with the eighth bit available for parity (if desired). The international equivalent to this is the 7-bit ISO (International Standards Organization) code. However, other encoding techniques may be utilized to compress information on these 8 lines. Information transferred includes interface commands, addresses, and device dependent data (discussed later with the ATN management line).

The transfer of the 3 byte sequence "BUS" would occur as shown here over the Data Lines. Hence the BIT PARALLEL . . . BYTE SERIAL description.



ASCII/ISO	B	U	S
Decimal	66	85	83
Octal	102	125	123
Hexadecimal	42	55	53

Data bus format

OVERVIEW

b. HANDSHAKE LINES — 3 lines used to coordinate the transfer of data over the data bus from a source (an addressed talker or a controller) to an acceptor (an addressed listener or all devices receiving interface commands) to ensure data transfer integrity. This technique has the following characteristics:

1. Data transfer is asynchronous and the transfer rate automatically adjusts to the speed of the sender and receiver(s) and runs at the rate of the slowest active device.
2. More than one device can accept data at the same time.
3. Every byte transferred undergoes the handshake.

NOTE

HP-IB signal lines use a low-true logic convention to implement the wired or convention of the NRFD and NDAC lines, provide active true-state assertion, and reduce noise susceptibility in the true state.

The three handshake lines are:

DAV — Data Valid. This line is controlled by the source (active talker or controller).

NRFD — Not Ready For Data. This line is controlled by the acceptors (active listeners) or all devices receiving interface commands.

NDAC — Not Data Accepted. This line is controlled by the acceptors (active listeners) or all devices receiving interface commands.

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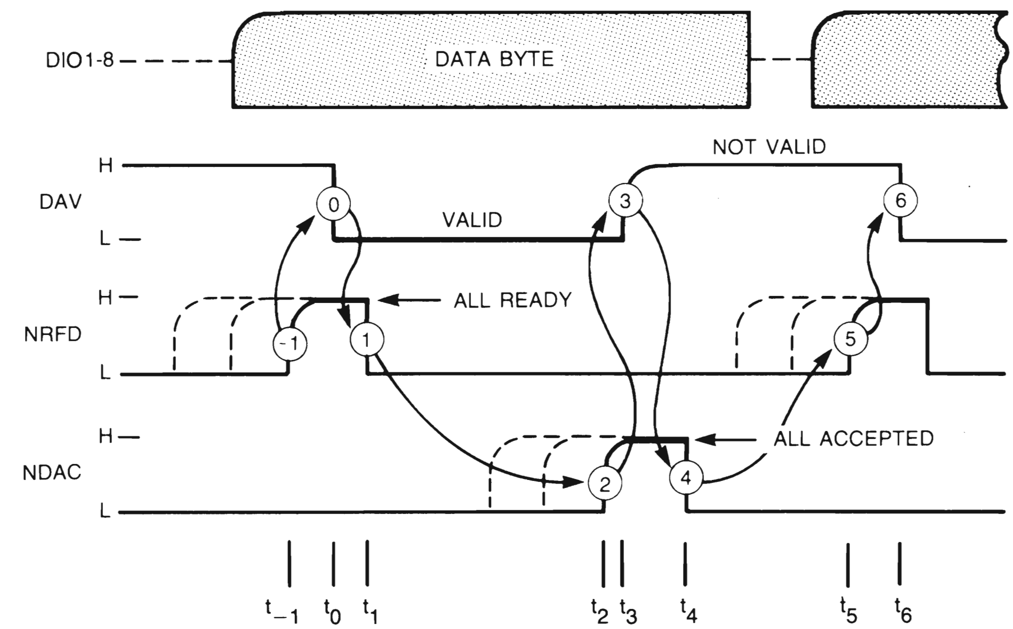
The handshake timing sequence is illustrated in the following figure:



Data byte transfer

Preliminary: Source checks for listeners and places data byte on data lines.

t_{-1}: All acceptors become ready for byte. NRFD goes high with slowest one.

t_0: Source validates data (DAV low)

t_1: First acceptor sets NRFD low to indicate it is no longer ready for a new byte.

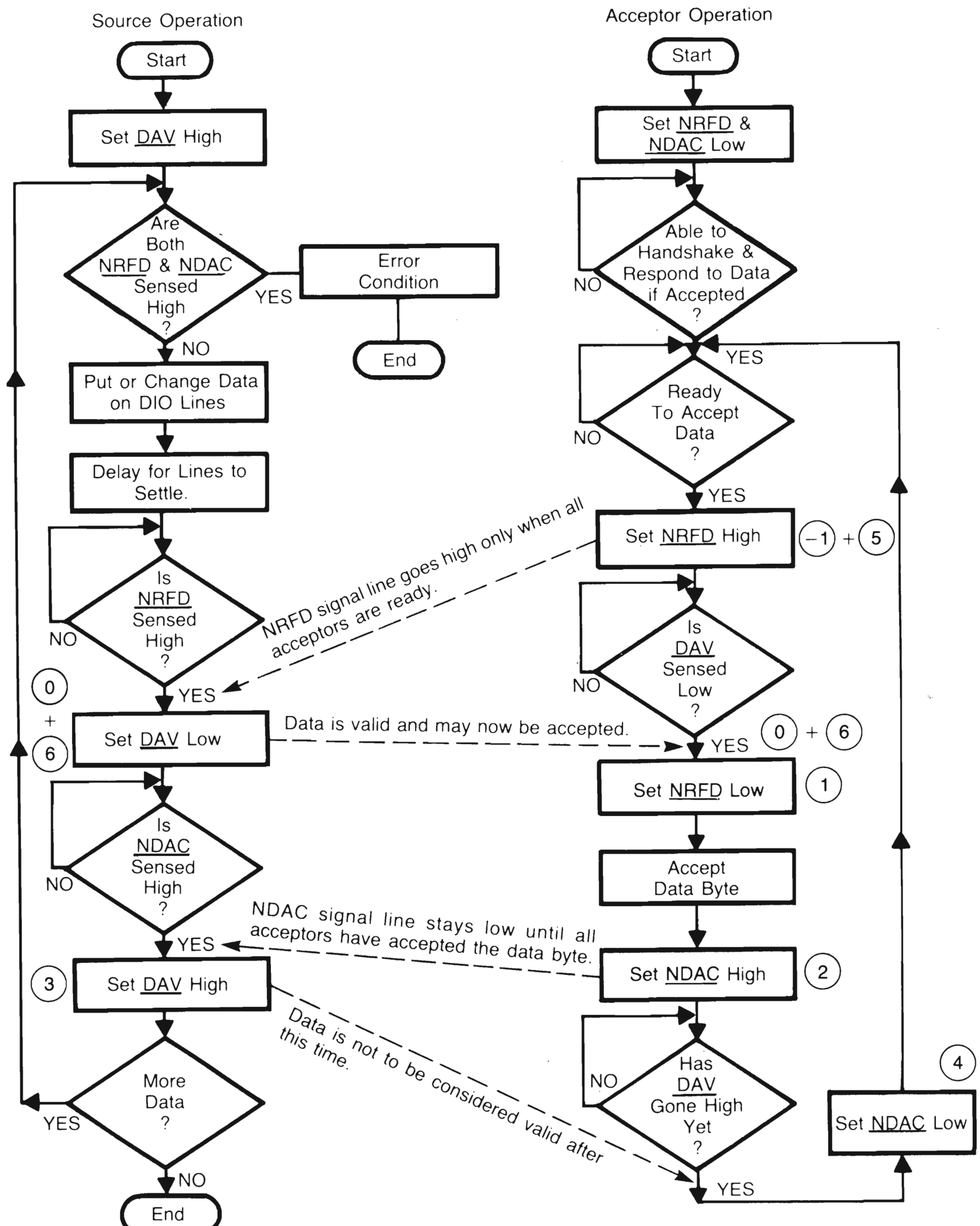
t_2: NDAC goes high with slowest acceptor to indicate all have accepted the data.

t_3: DAV goes high to indicate this data byte is no longer valid.

t_4: First acceptor sets NDAC low in preparation for next cycle.

t_5: Back to t_{-1} again.

The handshake sequence is depicted in flowchart form below:



Logical flow of events for Source and Acceptor when transferring data using the handshake process.

Handshake timing sequence

Hewlett-Packard's patent position on the three-wire handshake technique:

THREE-WIRE PATENT POSITION

- One Time Charge $250
- Company and All Subsidiaries
- No Disclosure Required

- Six Patents Issued:
  - U.S.A. Italy
  - Germany Switzerland
  - Holland United Kingdom
- Two Patents Pending:
  - France Japan

Patent position on three-wire handshake

TYPICAL QUESTIONS AND ANSWERS

Question: Why does HP-IB use a Low True Logic Convention?

Answer: To facilitate the wired-OR (logical-AND) use of the NRFD and NDAC lines, reduce noise susceptibility in the true state, and provide a low power passive false condition (HIGH) on the lines when not in use or disconnected.

Question: Why are 3 wires required for a simplex type of communication?

Answer: To ensure data integrity in a multiple listener (one fast, one slow) transaction. A GATE-FLAG (2-wire) type handshake might allow multiple acceptance of the same ASCII character.

Question: What about drivers? Terminations?

Answer: Open-collector drivers are typically used but tristate drivers are also allowed (speed advantage). The small signal AC Z_{in} (a standard load) is $<$2K in parallel with $\leq$100pf @ 2V measured at 1 MHz.

General Interface Management Lines — These 5 lines are used to manage an orderly flow of information across the interface:

NAME	MINEMONIC	DESCRIPTION
ATTENTION	ATN	CAUSES ALL DEVICES TO INTERPRET DATA ON THE BUS AS A CONTROLLER COMMAND AND ACTIVATE THEIR ACCEPTOR HANDSHAKE FUNCTION (COMMAND MODE) OR DATA (DATA MODE) BETWEEN ADDRESSED DEVICES.
INTERFACE CLEAR	IFC	INITIALIZES THE HP-IB SYSTEM TO AN IDLE STATE (NO ACTIVITY ON THE BUS).
SERVICE REQUEST	SRQ	ALERTS THE CONTROLLER TO A NEED FOR COMMUNICATION.
REMOTE ENABLE	REN	ENABLES DEVICES TO RESPOND TO REMOTE PROGRAM CONTROL WHEN ADDRESSED.
END OR IDENTIFY	EOI	INDICATES LAST DATA BYTE OF A MULTIBYTE SEQUENCE; ALSO USED WITH ATN TO PARALLEL POLL DEVICES FOR THEIR STATUS BIT.

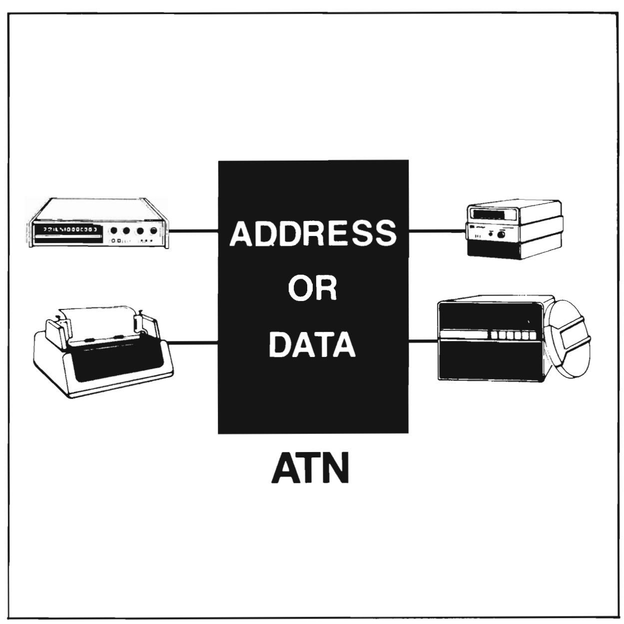
General interface management lines

ATN (ATTENTION)

All devices must monitor ATN at all times and respond to it within 200 ns.

true When true, ATN places the interface in the "COMMAND MODE" where all devices accept (handshake) data on the Data Lines and interpret it as COMMANDS.

false When false, ATN places the interface in the "DATA MODE" where the active talker sources device dependent DATA to all active listeners.



COMMAND MODE

The commands serve several different purposes:

1. Addresses, (talk or listen), select the instruments that will source and accept data. They are all multiline messages.
2. Universal commands cause every instrument equipped to so do to perform a specific interface operation. They include seven multiline commands and three uniline commands, interface clear (IFC), remote enable (REN), and attention (ATN).
3. Addressed commands are similar to universal commands, except that they affect only those devices that are addressed and are all multiline commands. An instrument responds to an addressed command, however, only after a controller has already told it to be a talker or listener.
4. Secondary commands are multiline messages that are always used in conjunction with an address, universal command, or addressed command (also referred to as primary commands) to provide additional command codes. Thus they extend the code space when necessary.

TALK AND LISTEN . . . ADDRESSES

Every HP-IB device has at least *one**. Device Addresses are used by the active controller in the COMMAND MODE to specify who talks (via a Talk Address) and who listens (via Listen Addreses). A device's address is usually pre-set at the factory and is resetable during system configuration by an address switch, jumpers, or front panel entry. This switch is typically located on the outside rear panel of the device but could be internal. The decimal equivalent of the 5 least significant bits of this switch determines the device's address on the interface and can be from 0 to 30 inclusive. Any given Device Address can specify two corresponding address codes on the Data Lines (although it may only actually respond to one):

1. A Talk Address
2. A Listen Address

The sixth and seventh bits (DIO6-DIO7) are used to distinguish between a device's talk and listen address characters. (High-level I/O drivers typically configure these two bits for you.) Changing a device's address switch changes both. Two address codes are used to tell every device to UNTALK (–) or UNLISTEN (?). Therefore, device address 31 is illegal and the maximum useable set totals 31 (zero base). Controllers usually treat HP-IB addresses via global variables, common memory, Logical Unit (LU) numbers, or symbol tables so that address changes require minimal program modification. Let's try an example.

*Unless it's totally transparent or a Talk or Listen Only device.

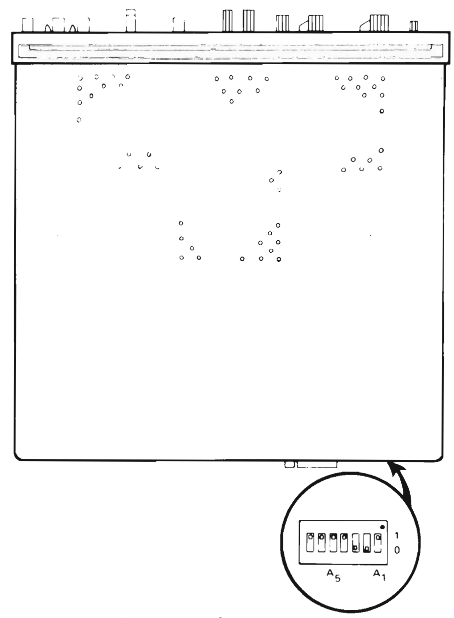
Say you wish to set a COUNTER for an HP-IB address of decimal 25 . . .

Decimal 25 corresponds to binary 11001 or octal 31. Locating the address on the back of the instrument, you set switches A1, A4, and A5 to "1" and switches A2 and A3 to "0".

Address Switch Numbers					Address Characters[1]		Octal Value	Decimal Value
5	4	3	2	1	Talk	Listen		
0	0	0	0	0	@	SP	00	00
0	0	0	0	1	A	!	01	01
0	0	0	1	0	B	"	02	02
0	0	0	1	1	C	#	03	03
0	0	1	0	0	D	$	04	04
0	0	1	0	1	E	%	05	05
0	0	1	1	0	F	&	06	06
0	0	1	1	1	G	'	07	07
0	1	0	0	0	H	(	10	08
0	1	0	0	1	I	)	11	09
0	1	0	1	0	J	*	12	10
0	1	0	1	1	K	+	13	11
0	1	1	0	0	L	,	14	12
0	1	1	0	1	M	–	15	13
0	1	1	1	0	N	.	16	14
0	1	1	1	1	O	/	17	15
1	0	0	0	0	P	0	20	16
1	0	0	0	1	Q	1	21	17
1	0	0	1	0	R	2	22	18
1	0	0	1	1	S	3	23	19
1	0	1	0	0	T	4	24	20
1	0	1	0	1	U	5	25	21
1	0	1	1	0	V	6	26	22
1	0	1	1	1	W	7	27	23
1	1	0	0	0	X	8	30	24
1	1	0	0	1	Y	9	31	25
1	1	0	1	0	Z	:	32	26
1	1	0	1	1	[	;	33	27
1	1	1	0	0	\	<	34	28
1	1	1	0	1	]	=	35	29
1	1	1	1	0	^	>	36	30
1	1	1	1	1	—	?	37	31

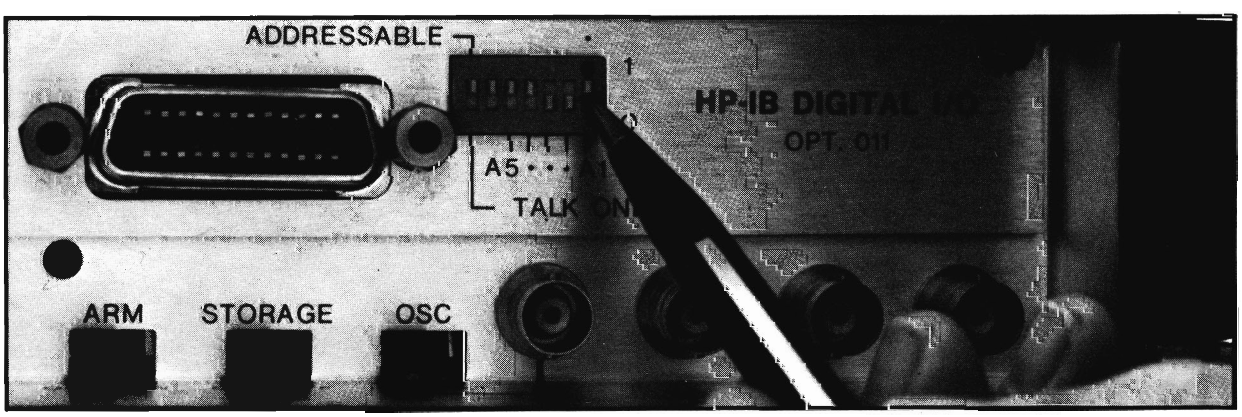
Talk and listen addresses

[1]Refer to Appendix A



← Address switch settings

A close-up on the COUNTER and address switch . . .



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The remaining switches on some devices (A6 and A7, etc.) are typically used to establish the device in Talk or Listen Only modes or to implement self-test features such as Signature Analysis or other service aids. Talk or Listen Only switches can be set to activate a talker or listeners without controller addressing (a controller-less system).

EXTENDED ADDRESSING — HP-IB devices with EXTENDED ADDRESSING capabilities (secondary commands) recognize an additional address character to establish some lower-level identity (a particular card or register in the device) as a talker or listener. Extended Talker and Listener capabilities are mutually independent in a device (e.g. you could have an HP-IB device which is an Extended Talker but only a Basic Listener, etc.).

MULTIPLE ADDRESSES — HP-IB devices with multiple device capabilities which can be treated individually (e.g. Plotter/Printers, etc.) may have more than one talk or listen address (as opposed to extended addresses).

Multiple-address devices typically use fewer switch address switches — 2 addresses require just four switches. A single setting will determine two talk addresses and two listen addresses. Four switches would control the A2 through A5 positions. (There is no switch for A1.) Setting these switches to a value of one produces two listen addresses of "2" and "3" in ASCII with two corresponding talk addresses of "R" and "S". Refer to the ASCII/ISO and IEEE code chart in Appendix A.

A5	A4	A3	A2	A1	(Notice no A1, therefore, switches are set for decimal 18, 19 or octal 22, 23)
1	0	0	1	—	

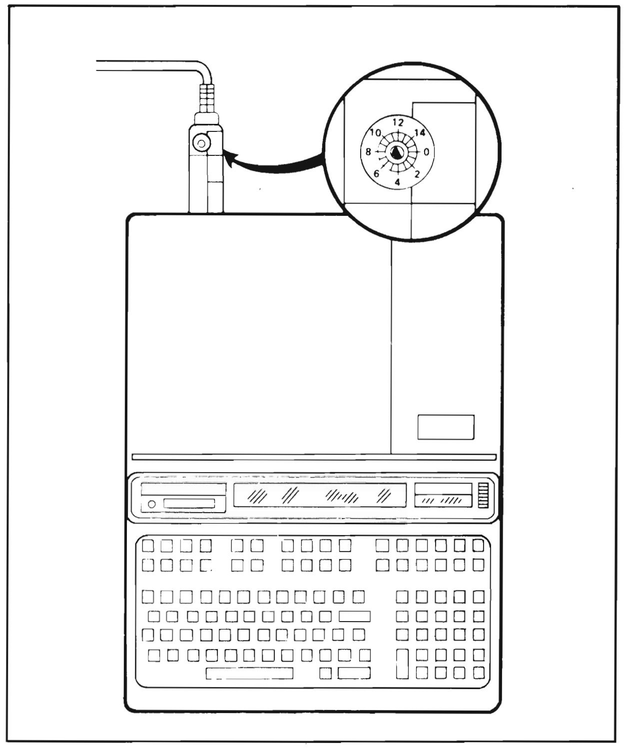
Example setting for dual-address device

OVERVIEW

A PRIMER ON INTERFACE SELECT CODES

Each HP-IB controller interface will also have a select code which allows controllers to access it and distinguish it from other interfaces in your system. The technique used to assign an interface to an interface will vary from controller to controller (controller DEPENDENT). Here are 2 common techniques:

SELECT CODES — Many Desktop Computers treat each interface as a Select Code which can be physically set on the interface card by a switch or jumpers. You may have to go inside the interface card to set the select code. The interface card may also have a switch or jumpers to establish it's HP-IB device address (since it is also a device on the HP-IB). Don't confuse these two distinct addresses.



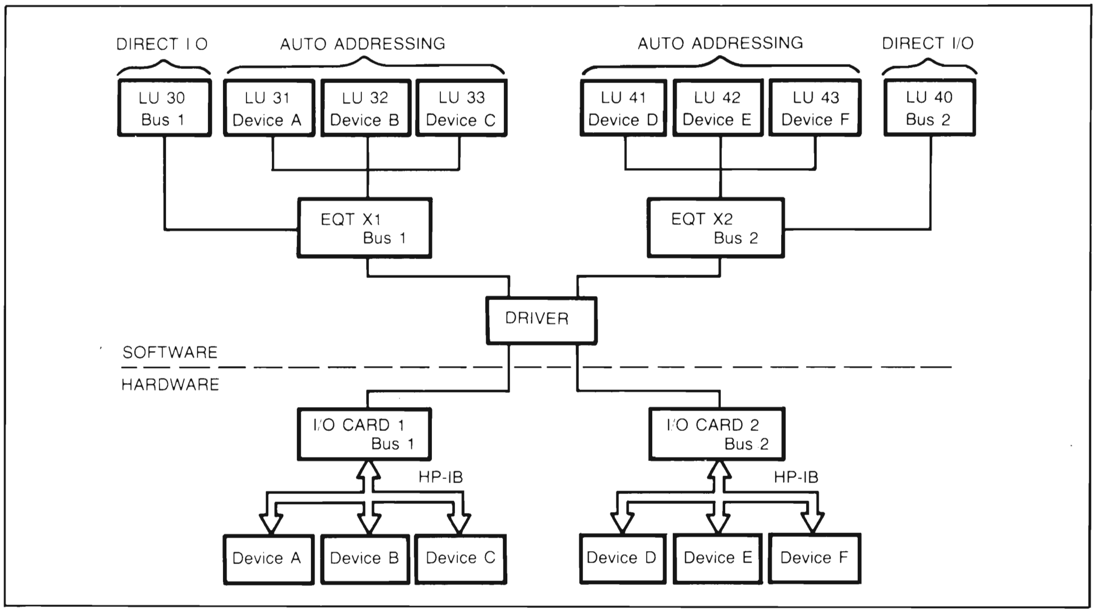
Interface addressing on a desktop computer (Select Codes)

LOGICAL UNITS — Many Minicomputers treat each interface as a Logical Unit (LU) number which is assigned by system software to the interface through a device reference table (DRT). The DRT points to an entry in an Equipment Table (EQT) which specifies the I/O slot*, name of driver, and other I/O information. This table is set up for a particular interface and is also used to equate available LU numbers with Device Addresses on that interface. HP-IB control is therefore accomplished via one LU to the interface (DIRECT I/O) or N LU's to N devices (AUTO ADDRESSING).

*Which is analogous to a Select Code.

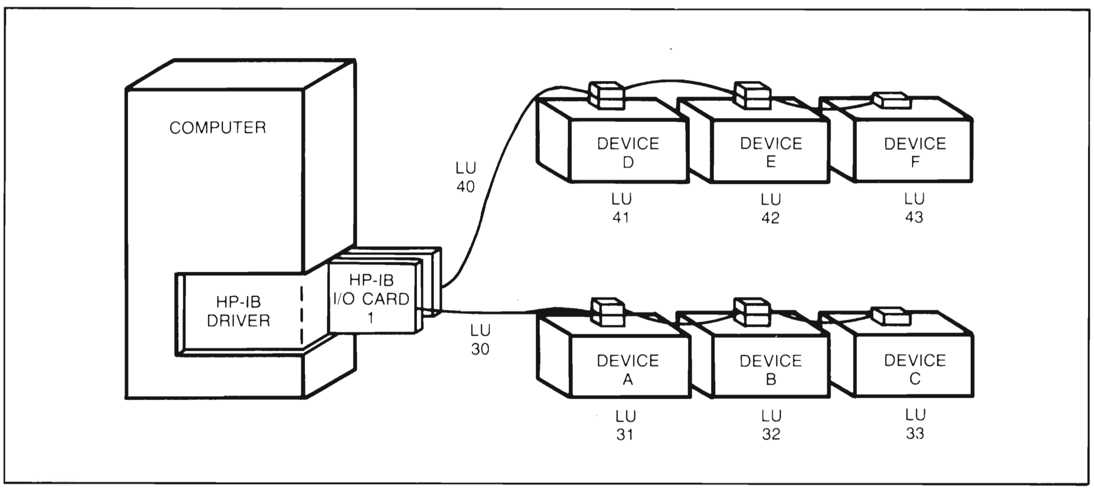
Interface addressing techniques (not part of standards)

A typical HP-IB addressing structure using LU numbers would be:



HP-IB addressing in a minicomputer (Logical Units)

Although hardware-wise the interfacing is still the same:



LU allocation to HP-IB devices

Other typical minicomputer LU allocations:

LU 0 — Bit bucket (scratch file)
LU 1 — System console
LU 2 — System disk
LU 3 — Auxiliary disk
LU 4,5 — Left and right terminal data cartridges
LU 6 — Printer
LU 7 — Reserved for local printer
LU 8 — Mag tape unit

Interface addressing techniques (continued)

UNIVERSAL COMMANDS

These consist of multiline and uniline commands. The seven multiline commands are:

Multiline Command	Mnemonic	Decimal Code	Octal Code	ASCII/ISO[1] Character
Untalk	UNT	95	137	—
Unlisten	UNL	63	77	?
Device Clear	DCL	20	24	DC4
Local Lockout	LLO	17	21	DC1
Serial Poll Enable	SPE	24	30	CAN
Serial Poll Disable	SPD	25	31	EM
Parallel Poll Unconfigure	PPU	21	25	NAK

Multiline Universal Commands

[1]Refer to Appendix A

Untalk Command UNT

The untalk command unaddresses the current talker. Sending an unused talk address would accomplish the same thing. This command is provided for convenience since addressing one talker automatically unaddresses others.

Unlisten Command UNL

The unlisten command unaddresses all current listeners on the bus. Single listeners cannot be unaddressed without unaddressing all listeners. It is necessary that this command be used to guarantee that only desired listeners are addressed.

Device Clear Command DCL

The universal device clear command causes all recognizing devices to return to a pre-defined device-dependent state. Recognizing devices respond whether they are addressed or not. Device manuals define the reset state for each device that recognizes the command.

Local Lockout Command LLO

The local lockout command disables a particular front-panel or rear-panel local-reset or return-to-local control (push button) on devices that recognize the command. Recognizing devices accept the command whether they are addressed or not. REN must be set false to re-enable the pushbutton, this also replaces all devices under local control.

Serial Poll Enable Command SPE

The serial poll enable command establishes serial poll mode for all responding talker devices on the bus. When they are addressed to talk, each responding device will return a single eight-bit byte of status from each device. Devices which recognize this command must have Talker interface capabilities to allow the device to output the status-byte.

Serial Poll Disable Command SPD

The serial poll disable command terminates serial poll mode for all responding devices, returning the devices to their normal talker state where they output device-dependent data rather than status information.

Parallel Poll Unconfigure Command PPU

The parallel poll unconfigure command resets all parallel poll devices to the idle (unable to respond to a parallel poll).

The three Uniline Commands are:

Uniline Command	Interface Management Line
Interface Clear	IFC
Remote Enable	REN
Attention	ATN

Uniline Universal Commands
(IFC and REN to be described later)

ADDRESSED COMMANDS:

The following table lists the addressed command group.

Addressed Command	Mnemonic	Decimal Code	Octal Code	ASCII/ISO Character
Group Execute Trigger	GET	08	10	BS
Selected Device Clear	SDC	04	04	EOT
Go to Local	GTL	01	01	SOH
Parallel Poll Configure	PPC	05	05	ENQ
	TCT			

Addressed Commands

Group Execute Trigger Command GET

The group execute trigger command causes all devices currently addressed to listen to initiate a preprogrammed action (e.g. trigger, take a sweep, etc.). Some devices may also recognize a device-dependent data character or string for this function (equivalent but requires entry into DATA MODE). The GET command provides a means of triggering devices simultaneously.

Selected Device Clear Command SDC

The *selected* device clear command resets device currently addressed to listen to a device-dependent state (e.g. turn-on state, open all relays, etc.). Device manuals define the reset state for each device that recognizes the command. Same as DCL.

Go to Local Command GTL

The go to local command causes the device currently addressed to listen to return to local panel control (exit the REMOTE state).

Parallel Poll Configure Command PPC

The parallel poll configure command causes the addressed listener to be configured according to the parallel poll enable secondary command which will follow.

SECONDARY COMMANDS

These consist of lower case ASCII alpha characters used for extended talk and listen addresses and secondary parallel-poll commands.

Secondary Command	Mnemonic	Octal Code	Decimal Code	ASCII/ISO Character
Parallel Poll Enable	PPE	140-157	96-111	I-O
Parallel Poll Disable	PPD	160	112	P

Secondary Commands

Parallel Poll Enable Command PPE

The parallel poll enable secondary command configures the devices which have received the PPC command to respond to a parallel poll on a particular HP-IB DIO line with a particular level. Some devices may implement a local form of this message (e.g. jumpers).

Parallel Poll Disable Command PPD

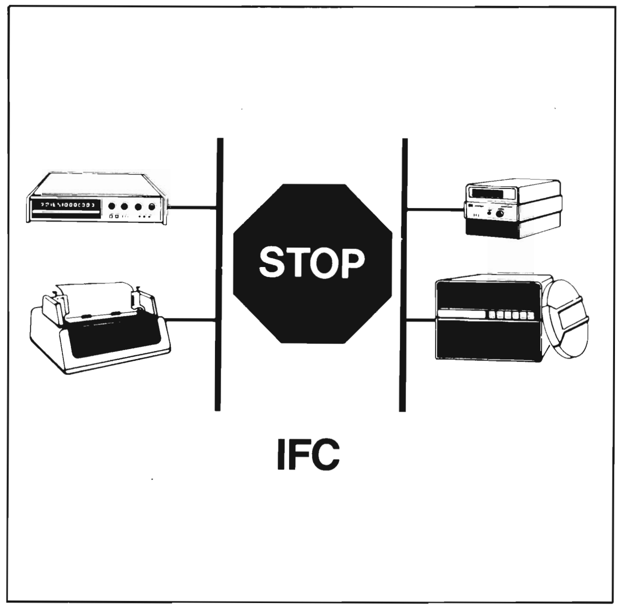
The parallel poll disable command disables the devices which have received the PPC command from responding to the parallel poll.

OVERVIEW

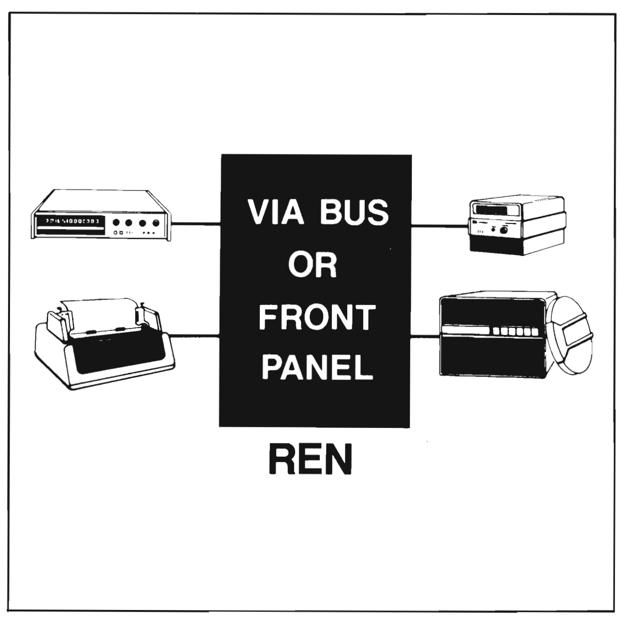
DATA MODE

In the DATA MODE (ATN false) device dependent data (e.g. programming data, measurement data, or status data) is sent from the active talker to the active listeners on the interface. The encoding and formatting of this data is an OPERATIONAL area issue of the interface and as such was beyond the range of the interface standards. A discussion of Hewlett Packard's experiences in DATA MODE code and format convention follows later in "Designed For Systems Aspects."

IFC (Interface Clear) — the IFC line is used only by the SYSTEM CONTROLLER to halt current operations (communications) on the bus (i.e. unaddress all talkers and listeners and disable Serial Poll). All devices must monitor IFC at all times and respond within 100 μsec (minimum pulse width for IFC).

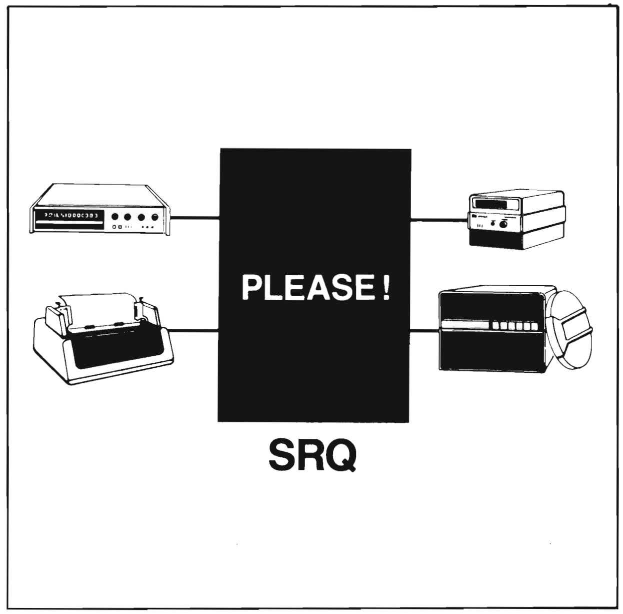


REN (Remote Enable) — The REN line is used only by the SYSTEM CONTROLLER to enable devices to be subsequently placed in the remote programming mode. When true, all listeners capable of remote operation are placed in remote when addressed to listen. When false, all devices return to local operation. All devices capable of both remote and local operation must monitor REN at all times. Devices must respond to REN within 100 μsec.



OVERVIEW

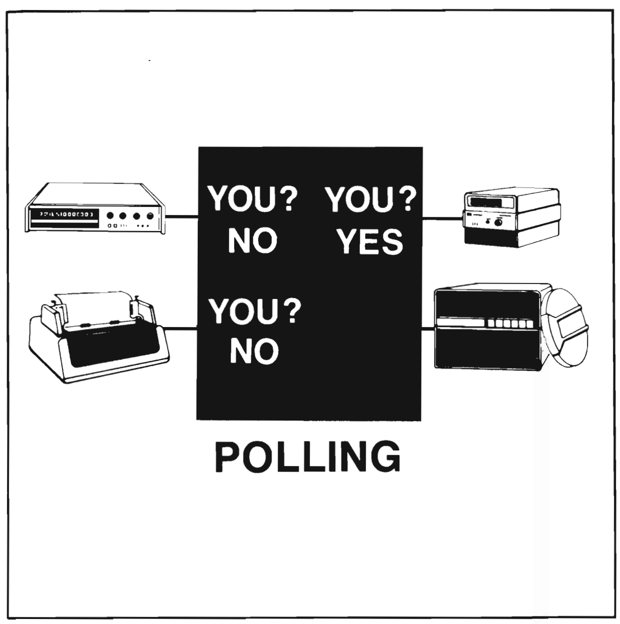
SRQ (Service Request) — The SRQ line is used by one or more devices to indicate the need for attention and can act as an interruption of the current sequence of events. Typically SRQ indicates data is ready to transmit and/or an error condition (e.g. syntax error, overload, trigger too fast, etc.) exists. The controller can mask the SRQ interrupt and must perform a SERIAL POLL of devices (when there's more than one) to determine who requested service and why.



POLLING

There are two possible polling procedures on the HP-IB:

1. SERIAL POLL
2. PARALLEL POLL



SERIAL POLL

A SERIAL POLL is a sequence which enables the controller to learn if a device or group of devices requires service and/or determine multi bit status of devices on the interface.

Devices which can be SERIAL POLLED will return a STATUS BYTE (requires Talker subset) to the controller to indicate their status under program control. The controller sequentially polls each individual device on the interface (sends a SPE if IFC is false and sequentially addresses devices to talk) and evaluates each status byte in turn. Therefore, this procedure can be lengthy in larger systems, but does provide the nature of the request at the same time as the identity of a requestor.

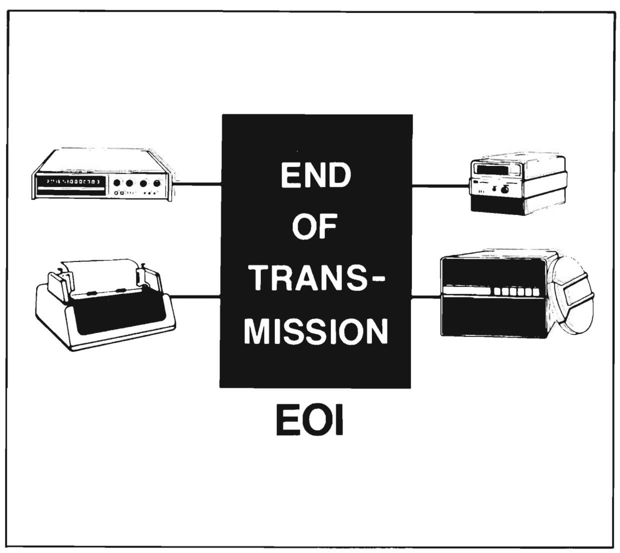
You should (although it's not mandatory) poll every device to be sure you find every requestor and remember to send Serial Poll Disable (SPD) and Untalk (UNT) commands when you're done with the procedure.

PARALLEL POLL

Parallel poll is a controller initiated operation to obtain information from the devices. When the controller initiates a parallel poll, each device returns a STATUS BIT via one of the DIO lines. Device DIO assignments are made by switches or jumpers or by the controller during the PPC (parallel poll configure) sequence. Devices respond either individually, each on a separate DIO line, or collectively on a single DIO line or any combination thereof. When responding collectively, the result is a logical AND or OR of the groups of status bits. Configured devices must respond to a PARALLEL POLL (the simultaneous assertion of ATN and EOI) within 200 nanoseconds. The controller can then read the results of the poll 2 microseconds later. Parallel poll is often used in the computer world to check the status of the action, i.e., which peripherals are ready for data, sending data or receiving data. By knowing this information dead times are reduced and the system bandwidth is used more efficiently.

EOI (End or Identify)

When ATN is true the EOI line is used by a controller to execute a parallel poll (already described). When ATN is false, the EOI line is used by an active talker to indicate the last byte of a data message (e.g. burst amplitude and phase measurements, programming strings, etc.)



Electrical aspects

General.

The relation between logic and voltage levels is:

Logic Level	Voltage Level
0 (False)	$\geqslant +2.0V$ (High)
1 (True)	$\leqslant +0.8V$ (Low)

Driver Types

Open Collector Only	Open Collector or *Tristate
SRQ, NRFD, NDAC	ATN, IFC, REN, EOI, DAV
DIO1-8 (Parallel Poll devices)	DIO1-8 (non-Parallel Poll devices)

*tristate useful to reach data rates above 250,000 bytes/sec.

Driver Specifications

$V_{OL} < +0.5V$ @ 48 ma continuous sink (tristate or open collector)

$V_{OH} \geqslant 2.4V$ @ 5.2 ma source (tristate)

see DC Load Line Graph (open collector)

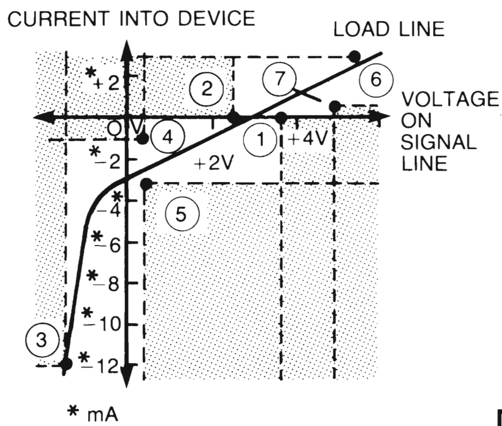
Receiver Specifications

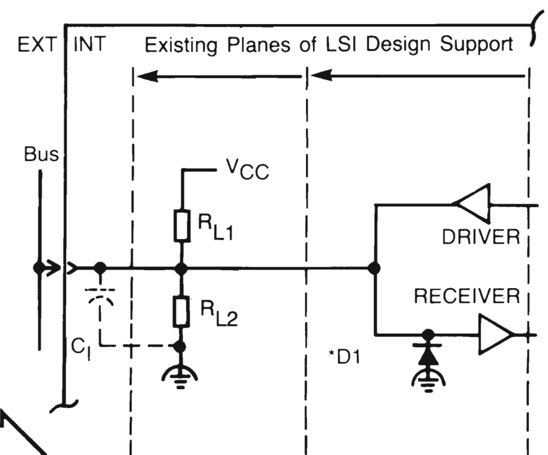
Preferred (Schmitt-type)	Allowed (non-Schmitt-type)
$V_{OH} \leqslant +0.8V$	$V_{OL} = V_{tneg} \geqslant +0.8V$
$V_{OH} \geqslant 2.0V$	$V_{OH} = V_{tpos} \leqslant +2.0V$
	Hysteresis: $V_{tpos} - V_{tneg} \geqslant +0.4V$

OVERVIEW

DEVICE LOAD REQUIREMENTS

The DC and small signal AC load requirements are summarized here and clarified with a typical circuit design:





Resistive Loading

(1) if I ≤ 0mA, V shall be <3.7V

(2) if I ≥ 0mA, V shall be >2.5V

(3) if I ≥ −12.0 mA, V shall be > −1.5V (only if receiver exists)

(4) if V ≤0.4 V, I shall be < −1.3 mA

(5) if V ≥0.4 V, I shall be > −3.2 mA

(6) if V ≤5.5 V, I shall be < 2.5 mA

(7) if V ≥5.0 V, I shall be >0.7 mA or the small-signal Z shall be ≤2 kΩ at 1 MHz

Note: The slope of the dc load line should, in general, correspond to a resistance not in excess of 3 kΩ

Capacitive Loading

$C_{internal\ (I)} \leq$ 100 pf @ <2V

V_{CC}:	+5V ± 5%
R_{L1}:	3.1 kΩ ±5% (to V_{CC})
R_{L2}:	6.2 kΩ ±5% (to ground)
Driver:	Output leakage current (open collector driver) +0.25 mA max at V_O = 5.25V Output leakage current (three-state driver) ±40 μA max at V_O = +2.4V
Receiver:	Input current −1.6 mA max at V_O = +0.4V Input leakage current +40 μA max at V_O = +2.4V +1.0 mA max at V_O = 5.25V

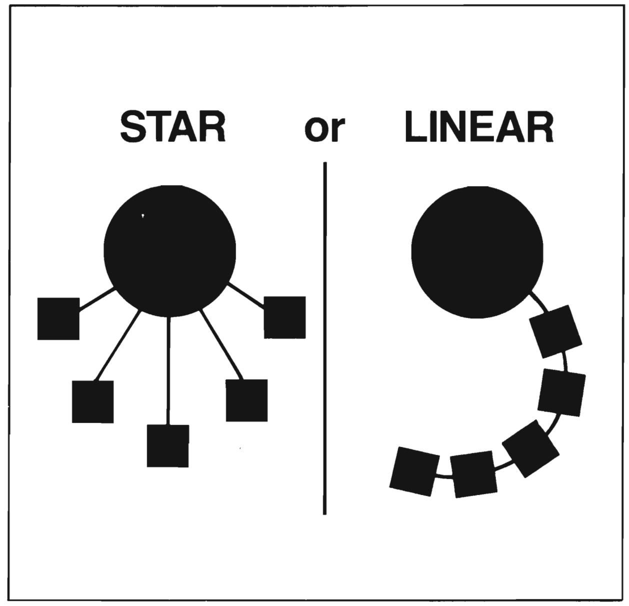
$C_I = C_{cabling} + C_{components} \leq 150$ pf/meter @ 1K Hz @ 0-5V

DESIGN SPECS (P/O STANDARD) ⇨ TYPICAL DESIGN

Converting electrical specifications to HP-IB transceiver circuit

Mechanical aspects

The connector, mounting, and cabling specifications of the interface define a flexible cabling system for interconnecting HP-IB devices. Devices can be interconnected in STAR, LINEAR, or combinational arrangements. An overall cabling restriction of 20 meters total or 2 meters per device, the lesser of the two, applies. For example, the maximum cable length is 4 meters if only 2 devices are involved. The length between adjacent devices is not critical as long as the overall restriction is met.



Cabling arrangements

OVERVIEW

Connector. The IEEE 488/ANSI MC1.1 connector is a 24-pin ribbon type connector with contacts assigned as shown here. A few key electrical and mechanical specifications:

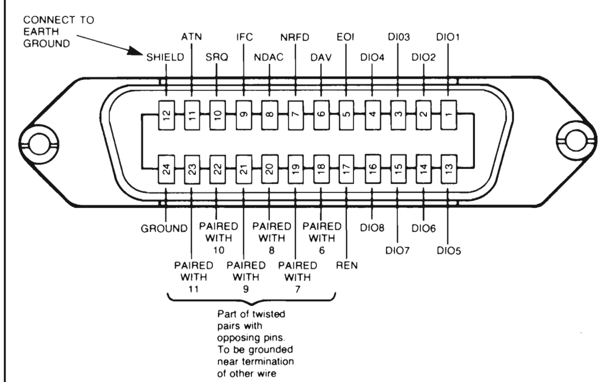
Voltage rating: 200 Vdc

Current rating: 5A

Endurance: ⩾1000 insertions

Temperature and Humidity:
MIL STD 202E

Suggested connectors:
Microribbon (Amphenol or Cinch Series 57) or Champ (AMP)



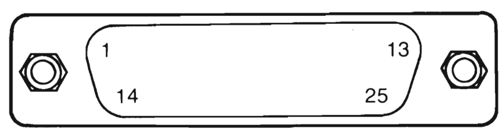
IEEE/ANSI connector

The IEC 625-1 connector is a 25-pin type connector (MIL-C-24308) with contacts assigned as shown here. A few key electrical and mechanical specifications:

Voltage rating: 60 Vdc

Current rating: 5A

Endurance: > 1000 insertions



(HORIZONTAL)

Contact	Signal line	Contact	Signal line
1	DIO1	14	DIO 5
2	DIO 2	15	DIO 6
3	DIO 3	16	DIO 7
4	DIO 4	17	DIO 8
5	REN	18	Gnd (5)
6	EOI	19	Gnd (6)
7	DAV	20	Gnd (7)
8	NRFD	21	Gnd (8)
9	NDAC	22	Gnd (9)
10	IFC	23	Gnd (10)
11	SRQ	24	Gnd (11)
12	ATN	25	Gnd (12)
13	shield		

IEC connector

Temperature and Humidity: IEC Publication 68 for climatic category 25/070/21.

Mounting. (IEEE/ANSI Connector)

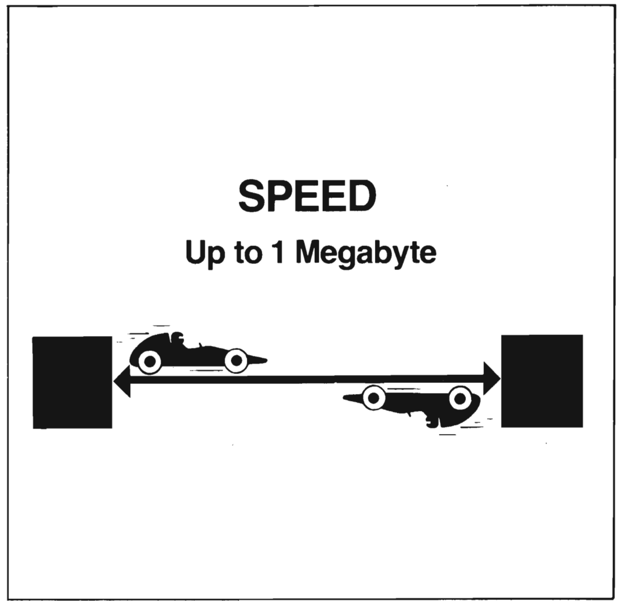
Metric threads (ISO M3.9 × 0.6 type) are specified. Metric fasteners are typically black. Some existing cables use English threads (6-32UNK). They are silver. DO NOT ATTEMPT TO MATE SILVER AND BLACK FASTENERS, as damage to hardware may result.

OVERVIEW

Designer guidelines from the IEEE-488

SPEED

With one device for every 2 meters of cable, the data rate can be 250 kbytes/second over distances of 20 meters using open collector drivers. Tristate drivers may increase the data rate to 500 Kbytes/second.



Question: How do I achieve data rates faster than 500 Kbytes/second?

Answer: First — Be sure all high rate devices use Tristate drivers (Interface capability I.D. E2) and that evey device is turned on.

Second — Minimize cable length! Do *not* exceed 15 meters total cable length and ensure one device for every meter of cable.

Third — Limit the capacitance of each device on each line to at most 50pf (@ $<$2V).

Fourth — All high rate Talkers should use a minimum multiline message settling time (T_1 in the IEEE-488 Standard) of 350 ns.

Also — Buffered data byte storage in a device is advantageous. Devices with a T_1 value less than 500 ns, an internal device capacitance of $\geqslant$50pf, or multiple resistive loads should be marked accordingly (typically done on CONTROLLERS).

See also IEEE standard 488-1978 section 5.2.

DEVICES POWERED OFF AND ON

Systems will operate normally with up to 1/3 of the devices powered off and even more as long as V_{OH} on each line on each device still exceeds the $+2.5$V specification. Turning on a device while a system is running may cause faulty operation.

Summary of 1978 revisions to IEEE 488/ANSI MC1.1

The November 1978 revision to the IEEE 488/ANSI MC1.1 standard was mostly (≈90%) for clarification. Heavy use in the seventies had brought out several areas of possible misinterpretation and several useful new guidelines/ recommendations.

IEEE STD. 488-1978
• EDITORIAL CLARIFICATIONS
• INTERFACE FUNCTION COMBINATIONS
• END MESSAGE CLARIFICATION
• SYNCHRONOUS TAKE CONTROL
• TRANSCEIVER SPECS
• HIGHER SPEEDS
• OPERATIONAL SEQUENCE
• CAPABILITY ID

Summary of 1978 revision

— Additional restrictions on allowable combinations of interface functions were added.

— Clarification of exactly how the END message is treated in source and acceptor interface functions was added.

— A minor revision to the CONTROLLER function (delay) was made to ensure against the possible simultaneous assertion of DAV and ATN which could be interpreted by idle devices as COMMAND MODE information, initiating a handshake sequence.

— The electrical specification for V_{OL}, the minimum low-state output voltage for bus drivers was raised to +0.5V to accommodate modern low-power Schottky drivers.

— More information was provided on how to maximize the Data Transfer rate over the interface.

— Warnings with guidelines about conducting and/or exiting particular operational sequences were added. For example, remembering to send Serial Poll Disable (SPD) followed by Universal Untalk (UNT) to exit each serial poll sequence.

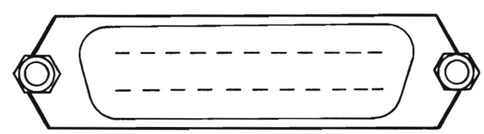
— A non-mandatory recommendation to mark the device's interface function codes and electrical driver type near the device's connector to aid the system designer and user.

CAPABILITY I.D.(NOT MANDATORY)

The ANSI/IEEE-488 recommends that all devices be marked near its connector with the interface function codes it supports.

For example, a device with the basic talker function, the ability to send status bytes, the basic listener function, a listen only mode switch, service request capability, remote local capability without local lockout, manual configuration of the parallel poll capability, complete device clear capability, no capability for device trigger, and no controller capability would be identified with these codes. →

IEEE STD 488 PORT



SH1, AH1, T2, L1, SR1, RL2, PP2, DC1, DT0, C0, E1

Capability I.D. codes

E1 identifies open collector drivers and E2 would identify tristate drivers.

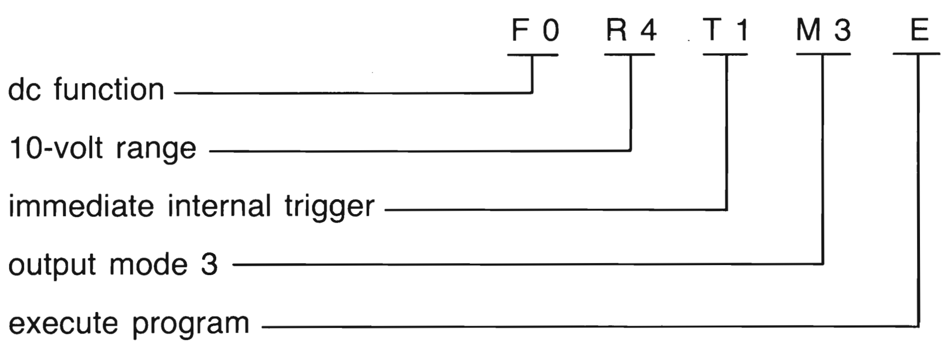
"Designed for systems" aspects

As we have already seen, Hewlett Packard's experience designing instrumentation and computation products for the system designer results in many "Designed for Systems" benefits to the final system designer, programmer, and user. Although these features are not required by the IEEE 488 or ANSI MC1.1 or IEC 625-1 Part 1, they are part of HP-IB. Let's review some of the "Designed for Systems" features of HP-IB components . . .

Operational aspects

EXPERIENCE IN THE DATA MODE

In the DATA MODE (ATN false) device dependent data (e.g. programming data, measurement data, or status data) is sent from the active talker to the active listeners on the interface. The encoding and formatting of this data is an OPERATIONAL aspect of the interface and as such was beyond the range of the interface standard. Experience in this area, however, has led to some agreed upon, generalized code and format structures for the DATA MODE. In general, the format for programming data strings used in typical Hewlett-Packard HP-IB products consist of sets of alphanumeric character sequences. One or more alpha characters identify a parameter and the numeric field identifies the parameter selection or value. Specific code assignments, however, are unique to each device. For example, the following message programs a voltmeter to measure a dc voltage on the 10-volt range upon receipt of an internal trigger, and then output the measured quantity.



The voltmeter's response to the command might be:

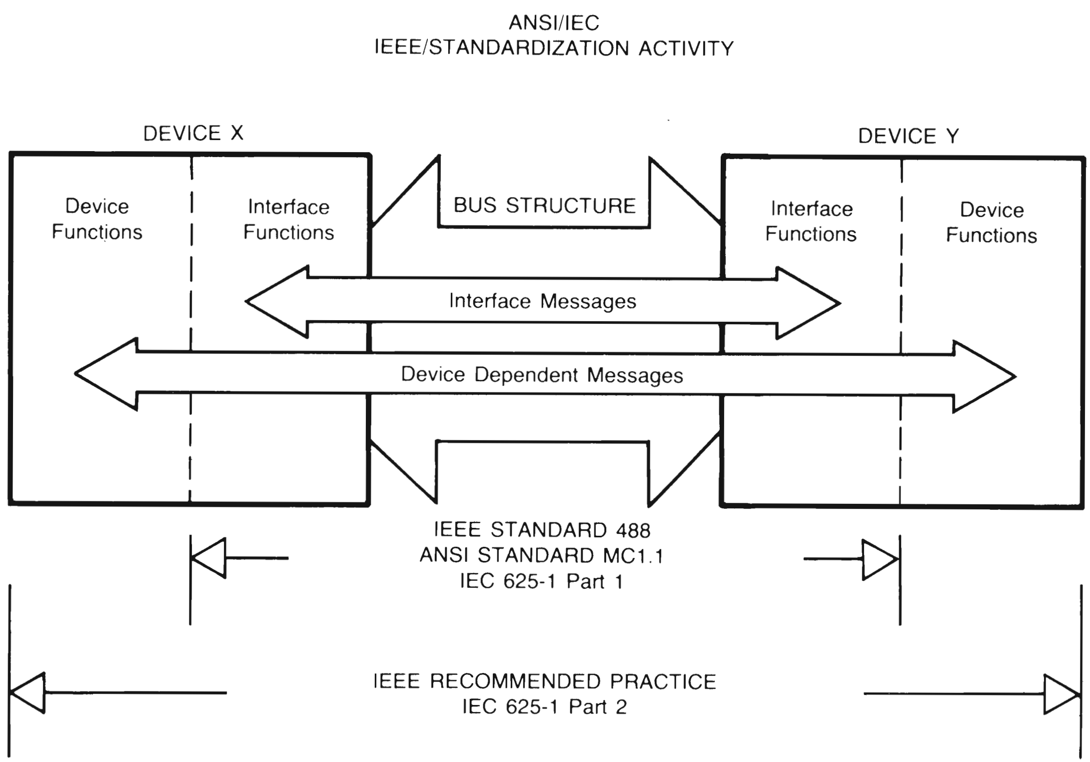
OLDC + 12002E - 03CRLF (EOI)

Here, the OLDC provides summary status data indicating that the measurement is a dc voltage but the value, in this case +12.002 volts expressed in exponential notation, is beyond the normal 10-volt range specified and is therefore flagged as an overload condition. This message can be divided into three fields: header (alpha only), numeric value representing the measured

Recommended practices in the data mode (device dependent) quantity, and separator or ending to the message (the carriage return/line feed concurrent with the EOI line on the bus). The overall structure of the format is defined but individual product implementations select the particular message elements appropriate for that product. For example; the instructions may be chosen to represent action (i.e. action oriented) or to represent a particular card (i.e. card oriented).

Standarization efforts are now in progress at national and international levels to provide a set of guidelines for the preferred syntax and formats applicable to products with ANSI/IEEE 488 capability. Balloting is expected to begin on the document, "IEEE Recommended Practices" in 1980. The international counterpart document from the IEC is currently designated "IEC 625-2 Part 2: Code and Format Conventions." The documents are technically very close although the IEEE document uses SYNTAX DIAGRAMS to help define and clarify the preferred code and format structures of data messages.

The standardization effort to date can be graphically depicted:



Recommended practices in the data mode (device dependent)

HP's HP-IB Interconnect cables offer improved shielding for reduced radiated emissions from cabling in systems environments. Here's some helpful info:

INTERCONNECTION RULES

An HP-IB system may be connected together in any configuration (star or linear or combination) as long as the following rules are followed:

1. The total number of devices is less than or equal to 15.
2. The total length of all the cables used is less than or equal to 2 meters times the number of devices connected together up to an absolute maximum of 20 meters.

The length between the adjacent devices is not critical as long as the total accumulated cable length is less than or equal to the maximum allowed. Star, linear, and combinational configurations are allowed.

METRIC HARDWARE

The mounting hardware uses metric threads (ISO M3.9x0.6). They are colored black. On some early (pre 1975) versions of the cables, the hardware used English Threads (6-32 UNC). These were silver color. DO NOT ATTEMPT TO MATE SILVER AND BLACK FASTENERS, as damage to the hardware may result. A metric conversion kit which will convert one cable and one or two instruments to metric hardware is available by ordering HP Part No. 5060-0138.

SPECIFICATIONS

MODEL NO.	LENGTH
10833A	1 m (3.28 ft)
10833B	2 m (6.56 ft)
10833C	4 m (13.12 ft)
10833D	0.5 m (1.64 ft)

It is recommended that no more than three of the connector blocks be stacked one on top of another as the resultant cantilevered structure can exert excessive force on the mounting panels when the stack of connector blocks becomes too long. The lock screws are designed to be tightened with the fingers only. Do not use a screwdriver. The screwdriver slots in the lock screws are provided for removal purposes only.

The new cables are completely compatible with, and can be used in combination with, the older style cables. However, this will affect the continuity and effectiveness of the shielding.

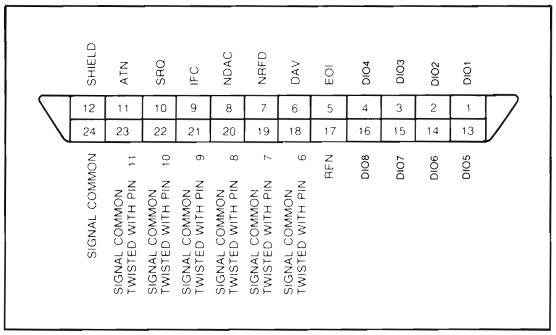
MATING CONNECTOR AND MOUNTING HARDWARE

ITEM/DESCRIPTION	HP PART NUMBER
Connector: 24-Pin Receptacle	1251-3283 (Amphenol 57-20240-2)
Mounting Stud, Long: For outside panel mounting (two required)	0380-0643
Lock Washer*: #8, split, 0.047" thick, for use with 0360-0643 (two required)	2190-0017
Mounting Stud, Short: For inside panel (.063" thick) mounting (two required)	0380-0644
Lock Washer: #10, split, for use with 0360-0644 (two required)	2190-0034

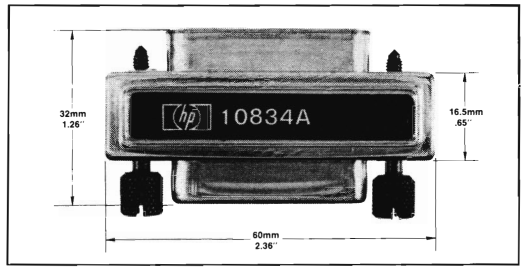
*NOTE: Use of specific lock washer is required to maintain spacing.

The HP 10834A adapter was designed to help in those cases where limited rear panel space and other design considerations have resulted in difficult cabling situations. The adapter extends the first cable approximately 2.3cm away from the rear panel to provide clearance for other connectors, switches and cables that may be in close proximity to the HP-IB connector.

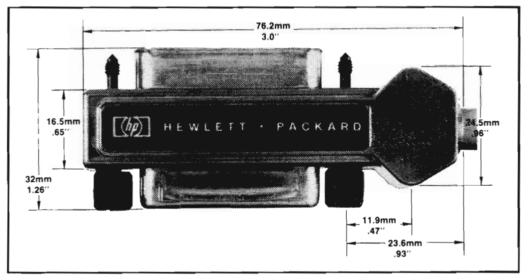
CONNECTOR DIAGRAM



ADAPTER DIMENSIONS



CONNECTOR DIMENSIONS



OTHER SYSTEMS-RELATED CABLING

You may find a single source for all your system cabling needs helpful. With that in mind:

- Toll Free, Direct Phone Ordering for U.S. Customers (800) 528-8787
  California: (408) 738-4133
- Shipment within 24 hours; guaranteed
- Easy to use reference guide in our new Computer Supplies Catalog.

Here is the current list:

Type of Cable	CSO Ordering Number	Description	HP Equivalent
HP-IB Cables	31389A	1 meter	10631A
	31398B	2 meter	10631B
	31389C	4 meter	10631C
HP-IB Cable (Low RFI)	10833A	1 meter	10833A
	10833B	2 meter	10833B
	10833C	4 meter	10833C
	10833D	.5 meter	10833D
HP-IB Adaptor	10834A	HP-IB Connector Adaptor/Extender — 2.3 cm	10834A
*RS-232C Cables	262X Terminals:		
	13222-60003	RS-232C Data Cable — 2 meters	13222C
	13222-60002	European Modem Cable — 5 meters	13222M
	13222-60001	U.S. Modem Cable — 5 meters	13222N
	13222-60007	262X to HP 300 — 5 meters	13222W
	264X Terminals:		
	02640-60058	HP 1000 CPU to Terminal — 15 meters	13232B
	5061-2409	European Modem Cable — 4.5 meters	13232M or 13232A
	02640-60049	264X to RS-232C — 1.5 meters	13232C
	02640-60131	U.S. Modem Cable — 4.5 meters	13232N
	Multipoint:		
	02640-60132	Multipoint Cable for first terminal — 4.5 meters	13232P
	02640-60133	Multipoint Cable for 2nd to 32nd terminal — 4.5 meters	13232Q
	02640-60134	Multipoint extension Cable — 30 meters	13232R
	02640-60151	Multipoint power protect — 9 meters	13232T
	5061-2410	264X to HP 300 — 6 meters	13232W
	Modem Cables:		
	30062-60020	7.6 meters	30062B
	30062-60021	15 meters connects **HP** 3000 to 103/202S modems	
	Modem Eliminators:		
	5061-2403	Modem eliminator, cable not shielded — 1.5 meters	13232U
	31390A	Modem eliminator, cable shielded — 5 meters	None
	Extender Cables:		
	31391 A, B, C & 30062-60012	Standard M/F RS-232C connectors with 25 pins wired end-to-end: A — 5 meters; B — 10 meters; C — 15 meters; 30062-60012 — 30 meters	30062C
	30062-60018	Hardwire extension cable, 3 wires — 30 meters	30062D

*For a more thorough list of RS-232-C Cables from Hewlett-Packard refer to HP P/N 5953-2450, "Computer Supplies Catalog", Spring 1980.

Additional helpful HP-IB information

RECENT DESIGN AND SERVICE AIDS

Among the most useful design aids for designing IEEE 488/ANSI MC1.1/IEC 625-1 capabilities into a product are:

- LSI chips for implementing CONTROLLER, TALKER, and LISTENER interface function combination
- A flexible BUS ANALYZER
- Timing Analysis for the bus (plus State Analysis)
- Serial Analysis for Data Communications and Interfacing applications in a Distributed Measurement Systems Environment.

LSI chip versions of the CONTROLLER, TALKER, and LISTENER interface functions are available (see next page) to facilitate your design process. These chips can implement selected functions or combinations. More recent chips include CONTROLLER capabilities (may be a separate chip). In all cases they typically replace between 40 to 60 MSI or SSI parts per function (Controller, Talker, Listener) on partially dedicated I/O boards. That's 120 to 180 parts for a full hardware version!

To perform the same functions via a typical MPU/ROM implementation might require 500 bytes per function. That's a full 1.5K bytes and a dedicated processor (e.g. an OUTGUARD processor in a DVM) as well. Here's a brief summary of LSI chips to date:

Comparison Of LSI Interface Chips

MANU-FACTURER	PART NUMBER	SUPPLY VOLTAGE (V)	CLOCK RATE (MHz)	POWER DISSIPATION (mW)		DATA TRANSFER RATE (BYTES/SEC)	SECOND SOURCE	FUNCTION	COMMENTS
FAIRCHILD	96LS488	5	10	*125°	LOW POWER SCHOTTKY	1M	NONE ANNOUNCED	TALKER/ LISTENER	LPS DRIVERS BUILT IN FOR ADDED NOISE IMMUNITY
***INTEL	8291 8292	5 5	8 6	500 625	NMOS	448K	NONE ANNOUNCED NEC	TALKER/ LISTENER CONTROLLER	8 MHz MPU REQUIRED
****MOTOR-OLA	MC68488	5	1 TO 1.5	600	NMOS	125K	FAIRCHILD AMI	TALKER/ LISTENER	REQUIRES 1 PAIR OF BUS TRANSCEIVERS
PHILIPS/ SIGNETICS (U.S.)	HEF4738V	4.5 TO 12.5	2	**1	CMOS	200K	NONE ANNOUNCED	TALKER/ LISTENER	MAY REQUIRE EXTERNAL MULTIPLEXERS, LEVEL SHIFTERS, DECODERS, DRIVERS
*****TEXAS INSTRU-MENTS	TMS9914	5	5	750	NMOS	250K	NONE ANNOUNCED	TALKER/ LISTENER CONTROLLER	ALL-IN-ONE DATA BYTE BUFFER SAFEGUARDS BUILT-IN

*With any three bus outputs in a low state. (Typical value 300 mW).
**When in a quiescent state at 10V.
***No support chips as yet (8293 Bus support chip coming).
****Support chips include MC3448 (hex transceiver) and MC3447 (octal transceiver).
*****SN 75160 data bus transceiver and SN 75162 management bus transceiver also available.

For more information on these products contact the following manufacturers:

Fairchild Semiconductor
464 Ellis St.
Mt. View, CA 94042
(415) 962-5011

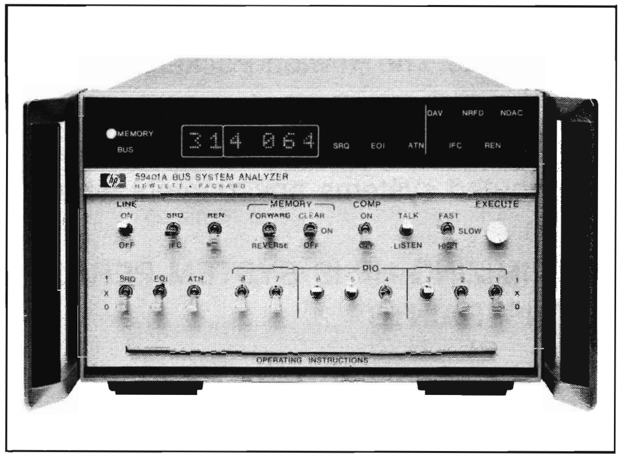
Intel Corp.
3065 Bowers Av.
Santa Clara, CA 95051
(408) 987-8080

Motorola Integrated Circuits Div.
3501 Ed Bluestein Blvd.
Austin, TX 78721
(512) 928-6800

Signetics Corp.
Box 409
Sunnyvale, CA 94086
(408) 746-1676

Texas Instruments Inc.
Box 1443, MS 6404
Houston, TX 77001
(713) 776-6511

A flexible BUS ANALYZER is a very useful product for aiding the HP-IB hardware/software designer in development and diagnosing HP-IB hardware/software problems. Most BUS ANALYZERS operate with complete TALKER, LISTENER, CONTROLLER, and SYSTEM CONTROLLER Interface Function capabilities which are mutually independent and exhibit near-ideal (typically <750 ns with <200 ns possible) accept times (T_3 in the IEEE-488 standard) for almost complete transparent bus monitor and test applications. Other applications include device and controller simulation and interface function verification.



Hewlett-Packard's Bus Analyzer . . . the 59401A

TIMING ANALYSIS is sometimes useful when optimizing/characterizing HP-IB product or system performance; or when diagnosing noise, timing, or software synchronization related faults in a product or system. Most TIMING ANALYZERS provide at least the 16 channels required to monitor HP-IB signal lines and more than enough bandwidth. 8 bits of TIMING and 16 bits of STATE analysis at up to 20 MHz can be provided as with Hewlett-Packard's Model 1615A Logic Analyzer.

SERIAL DATA ANALYSIS (MONITORING or DTE/DCE Simulation) is sometimes useful when you expect your HP-IB Measurement System to be or evolve into a Measurement Node in a larger distributed system environment via a serial network link or HP-IB extension technique. The network link would tie the local measurement-intensive system to a centralized computational-intensive system via a local networking scheme (Public Data Networks). A serial network link would also be of use for emulating a terminal via an ASYNCHRONOUS format or for Remote Job Entry (RJE) type applications for accessing the shared resources of the larger host (IBM 360/370) computer in the network via a SYNCHRONOUS format (Bisync, HDLC, SDLC, etc.). Other applications would also include any use of specialized RS-232-C instrument interfacing for adding older or non-IEEE-488/ANSI MC1.1 instruments and peripherals, or perhaps if a Factory Data Link (FDL) terminal will be utilized in your instrumented system to capture data throughout your automated production process.

A SERIAL DATA ANALYZER is an invaluable tool for developing and maintaining these links. The Hewlett-Packard Model 1640B is a general purpose SERIAL DATA ANALYZER for monitoring or simulating serial communications between Data Terminal Equipment (DTE) and Data Communications Equipment (DCE) in such a distributed systems environment whenever a serial interface is required.

OPTIMIZING HP-IB SYSTEM PERFORMANCE AND OVERCOMING CONSTRAINTS

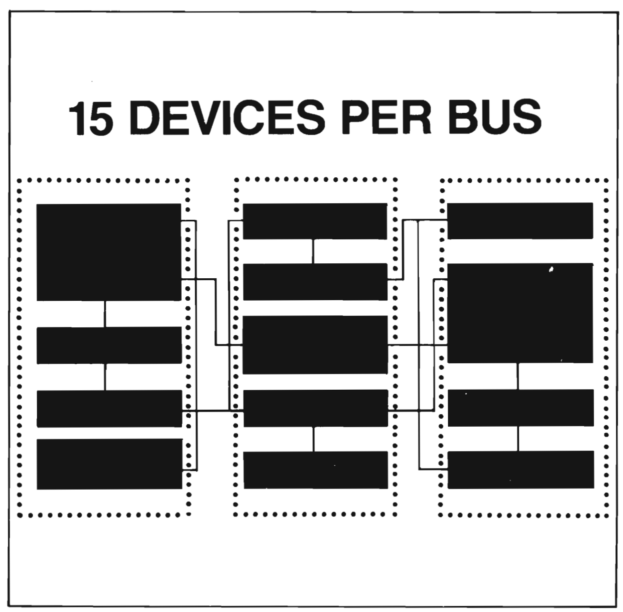
There are three areas of HP-IB performance that are most often asked about. These are:

- Surpassing the 15 device-per-bus constraint (Number of Devices per Bus).
- Surpassing the 20 meter total cable length constraint (Total Accumulated Cable length).
- Maximizing the data transfer rate of the interface. (Maximum Transfer Rate).

Each of these topics is discussed separately.

NUMBER OF DEVICES PER BUS

15 devices fills about three 56-inch bays with equipment and constitutes a fairly elaborate system. In most cases, this is not a major restriction. If you should have a need for more devices you can use an additional interface (another card in your desktop or minicomputer). If you run out of slots, some computers have I/O EXPANDERS for increasing the number of slots available.



About 3 bays

For HP computers:

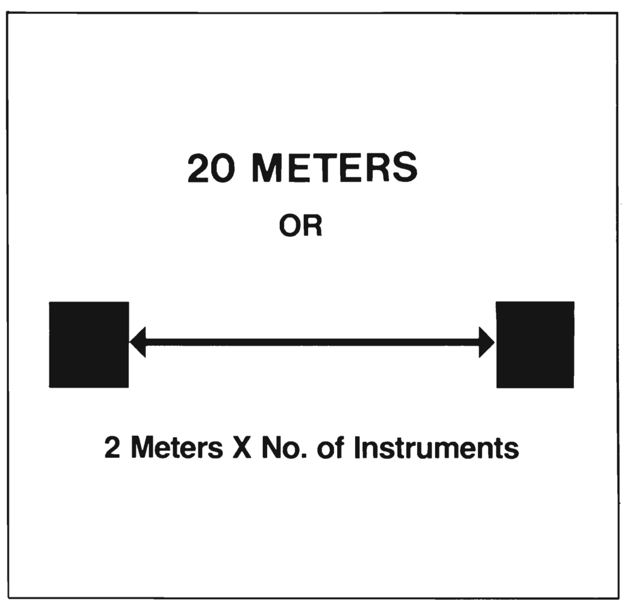
HP COMPUTER	# COMPUTER I/O SLOTS	HP INTERFACE CARD	HP I/O EXPANDER	# EXPANDER I/O SLOTS	MAX # OF EXPANDERS
85	4	82937A	None	NA	NA
9825	3	98034A Opt. 25	9878A	6	to HP-IB address limitation
9835	3	98034A Opt. 35	9878A	6	to HP-IB address limitation
9845	4	98034A Opt. 445	9878A	6	to HP-IB address limitation
1000 M, E, F	*16 maximum	59310B	12979B	16	2
1000 L	*13 maximum	12009A	None	NA	NA

*very dependent on system peripheral requirements. Typical maximums given.

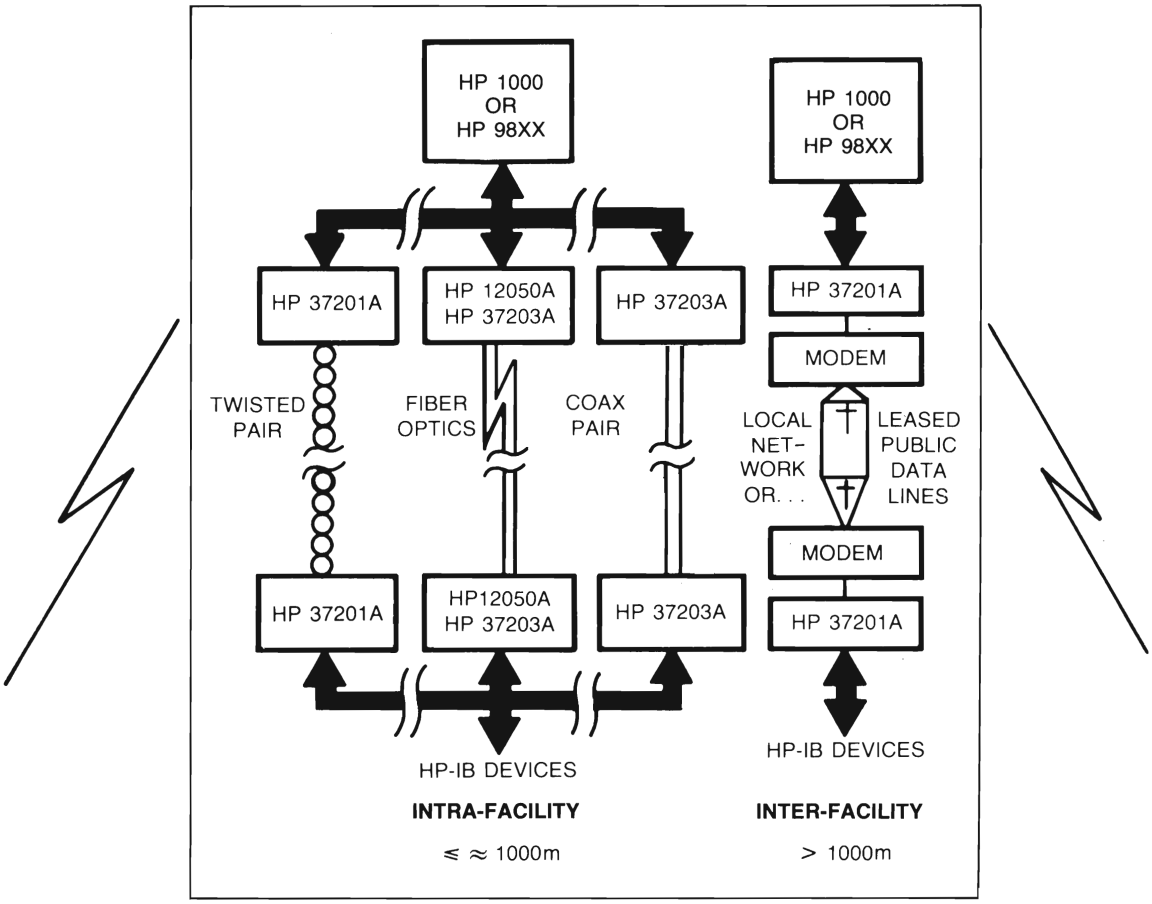
TOTAL ACCUMULATED CABLE LENGTH

For data rates below 500K bytes/second you are constrained to 20 meters total or 2 meters per device, whichever is less. There are 2 techniques for surpassing this limitation:

1. INTRA FACILITY HP-IB EXTENSION — for extending HP-IB capabilities up to 1000 meters via dedicated line media (twisted wire pair, co-axial cable, or fiber optics)



The cable length restriction



Extending the HP-IB

Intra Facility HP-IB Extension Can:	Inter Facility HP-IB Extension Can:
a. Extend HP-IB capabilities up to 1000 meters away. b. Save you money on cabling (can be up to $10/ft!). c. Avoid the cost of additional computers. d. Protect your computer from harsh environments, extreme noise, or unwanted user access. e. Preserve HP-IB flexibility at the remote end of the extension. f. Be partially (37201A, 12050A) or totally (37203A) transparent to the user.	a. Provide all of the benefits of Intra-Facility over unlimited distances with leveraged savings. b. Provide you with auto dial-up on one or more remote instrument clusters.

MAXIMUM TRANSFER RATE*

You'll find for most instrumented systems your throughput limited by the instruments in the system. Precision measurements typically take time relative to the microsecond cycle times in desktop or minicomputers. High resolution (5½ - 6½ Digit) voltage measurements using integrating analog-to-digital techniques, precision low frequency counting, and narrow band spectrum analysis are all good examples of relatively slow real-time measurement processes. As instruments and peripherals get smarter and digital signal processing becomes easier and less expensive to implement in instruments, the short term (high-speed sampling, burst measurements, computer "dumps", block memory transfers, DMA's) HP-IB demands will increase. In these cases the system throughput can become bound by the transfer rate of the computer-interface combination. For HP's HP-IB Interface Cards and HP-IB Extender the theoretical transfer rate limitations are:

	HP CARD (COMPUTER) OR EXTENDER	THEORETICAL MAXIMUM TRANSFER RATE (BYTES/SECOND)
Interface* Cards	82937A (85)	26.2K
	98034A (9825/35/45)	40K
	59310B (1000 M, E, F)	768K
	12009A (1000 L)	1M
Bus Extension Devices	37201A HP-IB Extender	750**
	12050A/B Fiber Optic HP-IB Link	20K
	37203A HP-IB Extender	50K

*Only limits transfers through the interface card itself, not over the entire cabling system.

**Speed is determined by modem baud (bit) rate when used for INTER-FACILITY applications.

Interface transfer rate limitations

*See also p. 32 "Designer guideline from the IEEE-488".

Suggestions for improving software performance

If speed is critical in your application the following guidelines may prove useful:

GENERAL (DEVICE DEPENDENT)

1. Familiarize yourself well with the operational aspects of the devices you're optimizing your routines for. Newer devices have fast-handshake and speed-advantageous features (e.g. buffering, program storage, hardware overlap, etc.) built-in.
2. Interrupt drive the process and down-load smart devices where possible. Some card-cage type instruments can perform many time consuming tasks through hardware features that otherwise might require significant software dedication and the associated overhead.
3. Avoid unnecessary unaddressing and readdressing steps where possible.
4. Use HP-IB Commands rather than device dependent messages where possible.
5. Suppress unneeded terminators.
6. Use system commands (already optimized) and binaries when they exist.
7. Get to know your HP-IB Specialist and Systems Engineers if you use HP equipment. They're highly trained specialists with timely answers to critical questions when you need them. Systems Engineers are also available on a consulting basis for a fee when you need dedicated consulting.

LANGUAGE DEPENDENT

1. Develop the driver at the lowest-level possible and appropriate (e.g. assembly for repetitive fixed point processes, interface control for single interface commands, micro-code for FORTRAN, etc.). But develop larger programs and non speed-critical subprograms at higher levels as appropriate.
2. Use compiled languages when available, HP1000 FORTRAN. If you can link compiled modules in an interpretive environment you may find its speed advantageous.

COMPUTER DEPENDENT (for HP Computers)

1. Reference formats (images) outside loops:

   9825, 9835, 9845, 1000 M, E, F, L

2. Reference images inside loops:

   85

3. Use multiple statements per line where possible:

   85, 9825

4. Declare variable types for loop indices as follows:

85	REAL (DEFAULT)
9825	N/A
9835	INTEGER
9845	INTEGER

5. Turn the CRT OFF on the 9835A when unneeded. This may also apply to instruments where turning off a display, auto-zero, or other such feature can improve measurement throughput when not needed. Check the devices manual when unsure!

6. Follow the IEEE-488/ANSI "Designer Guidelines" presented earlier in the Technical Overview.

Generally helpful information

Avoiding Typical HP-IB System Related Problems. Some suggestions to help things go smoothly:

1. Use an ALGORITHMIC DESIGN approach. It's simple, well structured, and has a history of success.

   a. DEFINE your system needs well.
   b. DESIGN the system solution.
   c. EVALUATE the expected cost-effectiveness of your design.
   d. BUILD the chosen solution.
   e. USE the system once built.

2. Order system prestudy or device manuals and application notes as early as possible.

3. An HP-IB BUS IMPLEMENTATION WORKSHEET is sometimes useful to visualize the ADDRESS and MESSAGE compatability of the devices in your system. This technique can aid the system programmer in larger HP-IB systems. Once you've got documentation on the devices, the programmer can fill in the SEND and RECEIVE message capabilities of the devices vertically and compare horizontally. A sample WORKSHEET is on the back of this page.

4. Develop hardware and software block diagrams or flowcharts for the tasks (measurement, test, control, data manipulation, presentation, etc.) you will need. You could do this while waiting for component or system delivery. Even better, do it as part of the DEFINING and DESIGNING steps of your system design.

5. Prepare the systems installation site adequately. Don't forget provisions for power distribution, interference protection, and such environmental considerations as temperature, humidity, static protection and physical clearances. Refer to the installation documents with your system and system components. A typical pre-installation planning checklist follows this page.

6. Appoint a system manager who is responsible for maintenance and calibration schedules, operator training, configuration control and systems logs as well as for ordering such consumables as paper, ink, diskettes, and cartridges. Giving the user this responsibility will typically result in further job enrichment and self-fulfillment.

7. Don't try to automate *too* much or the *wrong* things. Some interconnect processes may best be done manually to avoid the error terms associated with system switching. Many processes just do not make sense to automate (Microwave connections, etc.).

8. Take care when estimating software requirements for the system. Expect a decreasing exponential learning curve on test programs. The time to learn a mini-computer based system and write the first test is typically 10 times that required for an equivalent desktop computer based system. The steady state ratio drops to about 2 times as long as fluency and mastery are achieved.

9. The STAR cabling configuration will minimize worst-case transmission path lengths but can lump large capacitance values at a single plane on the line. The LINEAR cabling configuration may produce longer electrical lengths but provides more control to distribute capacitive line loads for maximum error-free transmission.

HP-IB BUS IMPLEMENTATION WORKSHEET															
MESSAGE		DEVICES													
INSTRUMENT IDENTIFICATION AND HP-IB ADDRESS	MODEL														
	LISTEN														
	TALK														
	5 BIT VALUE														
DATA															
TRIGGER															
CLEAR															
LOCAL															
REMOTE															
LOCAL LOCKOUT															
CLEAR LO & SET LOCKOUT															
REQUIRE SERVICE															
STATUS BYTE															
STATUS BIT															
PASS CONTROL															
ABORT															

S = SEND ONLY R = RECEIVE ONLY S & R = SEND AND RECEIVE N = NOT IMPLEMENTED

DIRECTIONS

1. Refer to Device's documentation to determine which HP-IB messages they implement and their factory selected addresses. (Factory selected addresses beginning page 55 for most current HP HP-IB products.)
2. Fill in the WORKSHEET
3. Where S and R capabilities line up horizontally, you've got message compatability!
4. Check to be sure if a "hardware" version of a message is available between devices otherwise triggering, clearing [blanking], END

INSTRUCTIONS.

Check when each planning question has been completed. If a question does not pertain to your installation, mark the question N/A.

Suitability of Site.

_______ 1. Is proper and adequate power available to site?

_______ 2. If below ground level, is the water drainage system adequate?

_______ 3. Has possible need for rigging been investigated?

_______ 4. Are elevators adequate to support size and weight of equipment?

_______ 5. Will stairways allow passage of equipment?

_______ 6. Will flooring enroute in installation site support weight of equipment?

_______ 7. Will all doorways enroute to installation site allow clearance for equipment?

_______ 8. Will hallways and corridors enroute to installation site allow clearance for equipment?

Floor Plan.

_______ 9. Has grid layout been completed?

_______ 10. Does it show the locations for all the proposed equipment?

_______ 11. Does it allow for adequate clearance in front and rear of the combining case or cabinet for operation and service?

_______ 12. Does it allow for future expansion?

_______ 13. Is sufficient space provided for personnel safe y, comfort and freedom of movement?

_______ 14. Does it show locations of all doors and aisle ways?

_______ 15. Is sufficient space provided for supplies?

Electrical Power.

_______ 16. Have tests been conducted to determine the voltage and frequency fluctuations throughout the day?

_______ 17. If tests indicated a greater than − 10% or + 5%fluctuation, have provisions been made for voltage or frequency regulation?

_______ 18. Have provisions been made for the installation of a sufficient amount of receptacles throughout the site for free-standing equipment?

_______ 19. Considering all factors such as wire size, distribution equipment, etc., is the proposed electrical installation plan adequate for the presently proposed system and possible future expansion?

Temperature.

_______ 20. Has the installation area been checked for minimum and maximum temperature ranges of 0°C (32°F) to 55°C (131°F) respectively?

Signal and Power Cables.

_______ 21. Have signal and power cable length restrictions been adhered to?

_______ 22. Will cables other than those supplied with equipment be required?

_______ 23. Will power plugs other than that supplied with equipment be required?

Safety Precautions.

_______ 24. Has the need for emergency exits been considered?

_______ 25. Have provisions been made for adequate number of CO_2 fire extinguisher?

_______ 26. Is there a FIRST AID KIT available at the installation site?

Pre-installation planning checklist

HP CONFIGURED SYSTEMS

Standard HP-IB Measurement Systems (HP Built)

Application	Model	Controller	System name/characteristics
	3052A	9825/35/45	Automatic Data Acquisition: fast and precise low-level measurements, powerful computation
	3054A	85/9825 9835/9845	Computer based Automatic Data Acquisition/Control System: fast flexible, and precise data acquisition system with a wide choice of controllers
Data Logging Acquisition, and Control	5391A	9825	Frequency and Time Data Acquisition Systems: over 50,000 four-digit frequency and time interval measurements per second
	9030	9825/35/45	Measurement and Control System: Fully configured, self-contained, and easy to use portable laboratory or production system for computational measurement and control.
	9875A	9825/35/45	Tape Cartridge Unit: Data logging applications
	3040A	9825	Network Analyzer: complete amplitude and phase characterization. 50 Hz to 13 MHz Group delay optional.
Network Analysis	3042A	9825	Automatic Network Analyzer: same as 3040A, and includes the 9825A as a computing controller
	8409A/B	9825/45	Automatic Microwave Network Analyzers: measures transmission and reflection parameters, 110 MHz to 18 GHz.
	8507B/C	9825/45	Automatic RF Network Analyzers: measures complex impedance, transfer functions, group delay: 500 kHz to 1.3 GHz
	3044A	9825	Spectrum Analyzer: precise amplitude and frequency measurements, 10 Hz to 13 MHz
	3045A	9825	Automatic Spectrum Analyzer: same as 3044A, and includes the 9825A as computing controller
Spectrum Analysis	8581A	9825	Automatic Spectrum Analyzer: covers 100 Hz to 1.5 GHz — exceptional frequency tuning accuracy and resolution
	8582A	9825	Automatic Spectrum Analyzer: covers 100 Hz to 22 GHz; exceptional frequency tuning accuracy and resolution

Standard HP-IB Measurement Systems (HP Built)

Application	Model	Controller	System name/characteristics
Frequency Stability Analysis	5390A	9825	Frequency Stability Analyzer: short and long-term characterization of precision frequency sources, 500 kHz to 18 GHz
Transceiver Testing	8950B	9825	Automatic Transceiver Test Systems: for AM and FM transceivers, to 1000 MHz, transmitters to 100 W
Circuit Testing	DTS-70	1000	Digital Test System: fast accurate fault location on loaded printed circuit boards
	3060A	9825	Analog and Digital Test Systems: Fast, accurate fault location on loaded printed circuit boards
Digital IC Testing	5046A	9825	Digital IC Test System: Reduces production costs through the isolation of faulty components prior to printed circuit board loading
FDM Network Surveillance	37013A	1000	Frequency Division Multiplex Network Surveillance System: remote capability based on HP 1000 Computer
	37014A	9835	Frequency Division Multiplex Network Surveillance System: remote capability based on 9835A Desktop Computer
Semiconductor/ Component Testing	4061A	9835/45 1000	Semiconductor/Component Test System: evaluation of fundamental characteristics of semiconductor and electronic components (I-V, HF C-V, + quasi static C-V)
Pressure Recording Package	2820A	9825	Shale deposit characterization system software for evaluation/production logging of bottom hole pressure in a producing oil or gas well
Graphics Display	1350S	9825	Graphics Display System with Digital Interface. High resolution display system for generation of bright, sharp vectors and alphanumerics at high writing speeds
Stimulus/ Response Testing	ATS-1000	1000	General Purpose Testing: Analog and Digital stimulus and, response for printed circuit boards and complete unit testing.

Typical factory selected HP-IB addresses (not guaranteed)

PRODUCT RELATED TO	MODEL	HP-IB DEC	HP-IB OCT	PRODUCT NAME/CHARACTERISTICS
Measurement	436A Option 022	13	15	Power Meter - 70 dBm to +44 dBm, to 26.5 GHz
	1602A Option 001	15	17	Logic State Analyzer: 64 × 16 bit memory
	1610A/B Option 003	15	17	Logic State Analyzer: 64 × 32 bit memory
	1615A Option 001	15	17	Logic Analyzer: 256 × 24 bit memory
	1640A Option 001	16	20	Serial Data Analyzer: 2048 bit memory
	1980A/B	07	07	Oscilloscope Measurement System; 100 MHz, fully programmable
	2240A	01	01	Measurement & Control Subsystem
	2250A	30	36	Measurement & Control Subsystem
	2804A Option 010	13	15	Quartz Thermometer: 0.05,C accuracy
	3437A	24	30	System Digital Voltmeter: high speed, 3½ digits
	3438A	23	27	Digital Voltmeter: low-cost 3½ digits
	3455A	22	26	Digital Voltmeter: 5½ or 6½ digits, auto calibration
	3456A	22	26	Digital Voltmeter: 3½ to 6½ digit voltmeter with variable integration times and 1 nv sensitivity
	3490A Option 030	22	26	Digital Voltmeter: 5 digits, self test
	3582A	11	13	2-channel Real Time (FFT) Spectrum Analyzer; 20 mHz to 25.6 kHz
	3585A	11	13	Swept Spectrum Analyzer: 20 Hz to 40 MHz, 3 Hz BW, 0.5% amplitude accuracy
	3586A/B/C	16	20	Selective Level Meter: 50 Hz to 32.5 MHz
	3717A	01	01	Wideband 70 MHz modem
	3724/25/26A	06	06	Baseband Analyzer
	3745A	10	12	25 MHz Selective Level Measuring Set: CCITT FDM systems
	3745B	10	12	25 MHz Selective Level Measuring Set: Bell FDM systems
	3747A	10	12	90 MHz Selective Level Measuring Set: CCITT FDM systems
	3747B	10	12	90 MHz Selective Level Measuring Set: Bell FDM systems
	3771A Option 005	03	03	Data Line Analyzer: CCITT measurement standards
	3771B Option 005	03	03	Data Line Analyzer: Bell measurement standards
	3779A	20	24	Primary Multiplex Analyzer: CEPT 2 Mb/s PCM systems
	3779B	20	24	Primary Multiplex Analyzer: Bell 1.5 Mb/s PCM systems
	3781B	04	04	Pattern Generator
	3782B	03	03	Error Detector
	4140A/B Option 101	17	21	PA Meter/DC Voltage Source
	4191A	17	21	RF Impedance Analyzer
	4192A	17	21	LF Impedance Analyzer
	4262A Option 101	17	21	Automatic LCR Meter
	4271B Option 101	17	21	1 MHz Digital LCR Meter
	4274A Option 101	17	21	Multifrequency LCR Meter: 10 steps, 100 Hz to 100 KHz
	4275A Option 101	17	21	Multifrequency LCR Meter: 10 steps 10 kHz to 10 MHz
	4943A Option 010	10	12	Transmission Impairment Measurement System (TIMS)
	4944A Option 010	10	12	Transmission Impairment Measurement System (TIMS)
	5312A	10	12	HP-IB interface (Talker) for 5300B Counter System
	5316A	20	24	Universal Counter: 0-100 MHz
	5328A Option 011	25	31	Universal Counter: to 512 MHz, 10 ns time interval
	5335A	03	03	Automatic Universal Counter: 200 MHz/1.3 GHz 2ns Time Interval
	5340A Option 011	03	03	Automatic Microwave Counter: 10 Hz to 18 GHz
	5341A Option 011	03	03	Automatic Microwave Counter: high speed, to 4.5 GHz
	5342A Option 011	02	02	Automatic Microwave Counter: 10 Hz to 18 GHz
	5343A Option 011	07	07	Microwave Frequency Counter: 10 Hz to 26.5 GHz
	5345A Option 011, 012	18	22	General Purpose Plug-In Counter1
	5353A	27	33	Channel C Plug-In for 5345A
	5354A	17	21	4 GHz Frequency Converter for 5345A/5356A
	5355A	09	09	Automatic Frequency Converter
	5356A	06	06	Synthesized Signal Generator: 100 kHz to 990 MHz
	5363A/B	17	21	Time Interval Probes
	5370A	03	03	Time Interval Counter: · 20 ps single-shot resolution
	5420A	04	04	Digital Signal Analyzer
	5423A	04	04	Dynamics Structural Analyzer
	5501A Option 251	09	11	Laser Transducer: for accurate positioning measurements
	6940B	23	27	Multiprogrammer (requires 59500 interface)
	6942A	23	27	Multiprogrammer II (no interface required)
	8501A	19	23	Storage Normalizer for 8505A RF network analyzer
	8503A & 8503B	20	24	S-Parameter Test Set: 50 or 75 Ohm for 8505A
	8505A	19/16	23/20	RF Network Analyzer, 500 kHz to 1.3 GHz Service/Processor
	8566A	18	22	Spectrum Analyzer: 100 Hz to 22 GHz
	8568A	18	22	Spectrum Analyzer 100 Hz to 1.5 GHz
	8901A	14	16	Modulation Analyzer: 150 kHz to 1.3 GHz
	8903A	28	34	Audio Analyzer: 20 Hz to 100 KHz
				Also see models 2240A, 2250A, 6940B, 6942A, and 3497A
Storage	3964A Option 007	17	21	Instrumentation Tape Recorder: 4 channel Listen only
	3968A Option 007	17	21	Instrumentation Tape Recorder: 8 channel Listen only
	9875A	04	04	Cartridge Tape Unit
HP-IB Extension	12050A/B	24	28	Fiber Optic Hp-IB link
	37201A	17	21	HP-IB Extender: Twisted Pair or modems
	37203A	NA	NA	HP-IB Extender: Co-axial or Fiber Optic Cable
	59403A	18/19	22/23	HP-IB Common Carrier Interface
Design and Servicing	59401A	NA	NA	Bus System Analyzer
	5004A Option Ho1	07	07	Signature Analyzer: Order K17-59994A for complete HP-IB
	10050A	NA	NA	HP-IB Adaptor for 1602A Logic State Analyzer
	10051A	NA	NA	Test Probe for 1602A Logic State Analyzer
	10066A	NA	NA	Probe Interface for 1610A/B and 1615A Logic State Analyzers

PRODUCT RELATED TO	MODEL	HP-IB DEC	HP-IB OCT	PRODUCT NAME/CHARACTERISTICS
Stimulus	3320B Option 007	19	23	Frequency Synthesizer: 0.01 Hz to 13 MHz
	3325A	17	21	Synthesizer/Function Generator/Sweeper: 1 GHz to 22 MHz
	3330B	04	04	Automatic Synthesizer/Sweeper 0.1 Hz to 13 MHz
	3335A	04	04	Synthesizer/Level Generator: 200 Hz to 80 MHz
	3336A/B/C	04	04	Synthesizer/Level Genérator: 10 Hz to 20.9 MHz
	4140A/B	14	16	PA Meter/DC Voltage Source
	5359A	04	04	Time Synthesizer: 1 ns accuracy: 50 ps increments, 100 Ps jitter
	6002A Option 001	05	05	DC Power Supply: 200 W autoranging Listen Only
	6129C Option J99	16	20	Digital Voltage Sources: ±50 Vdc at 5 A (requires 59301A Converter)
	6130C Option J99	16	20	Digital Voltage Source: ±50 Vdc at 1 A (requires 59301A Converter)
	6131C Option J99	16	20	Digital Voltage Source: ± 100 Vdc at o.5 A (requires 59301A Converter)
	6140A Option J99	16	20	Digital Current Source: ± 100 mA at 100 Vdc (requires 59301A Converter)
	6940B	23	27	Multiprogrammer (requires 59500A interface)
	6942A	23	27	Multiprogrammer
	8016A Option 001	17	21	Word Generator: 9 × 32 bit Listen Only
	8018A Option 001	17	21	Serial Data Generator: 50MHz, 2048-bit memory Listen Only
	8160A	17	21	Programmable Pulse Generator: 20 ns to 999 ms period
	8161A	17	21	Programmable Pulse Generator: 10 ns to 999 ns period
	8165A	15	17	Programmable Signal Source: 0.001 Hz to 50 Mhz
	8170A	17	21	Logic Pattern Generator: 8 × 1024/16 × 512 bit
	8350A	19	23	Sweep Oscillator: 10 MHz to 26.5 GHz
	8620C Option 011	06	06	Sweep Oscillator: 10 MHz to 22 GHz
	8656A	07	07	Signal Generator: 0.1 to 990 Mhz
	8660A Option 005	19	23	Synthesized Signal Generator: 10 kHz to 2.6 GHz Listen Only
	8660C Option 005	19	23	Synthesized Signal Generator: 10 kHz to 2.6 GHz Listen Only
	8662A	19	23	Synthesized Signal Generator: 10 kHz to 1280 MHz
	8671A	19	23	Microwave Frequency Synthesizer: 2 to 6.2 GHz
	8672A	19	23	Synthesized Signal Generator: 2 to 18 GHZ
Display	1350S	18	22	Graphics Display System
	2631A/G	05	05	Graphics Thermal Printer
	5150A Option 001	00	00	Alphanumeric Thermal Printer: 20 Columns Listen Only
	9871A Option 001	15	17	Character-Impact Printer: 132 columns
	7225A	05	05	Graphic Plotter: ISO A4 and 8½ × 11 inch chart size
	7245B	05/06	05/06	Thermal Plotter/Printer: Vector graphics, matrix printing
	7310A	01	01	Graphics Thermal Printer: Text, Graphics, and Forms
	9872B, 9872S	05	05	Graphics Plotter: multicolor (4 colors) programmable
	9876A	16	20	Thermal Graphics Printer: 480 lines-per-minute
Switching Scanning Translation or Timing	2240A	01	01	Measurement and Control Subsystem
	2250A	30	36	Measurement & Control Subsystem
	3495A	09	11	Scanner: to 80 channels, low thermal: (up to 40 relay channels) Listen Only
	3497A	09	11	Data Acquisition 1 Control Unit
	3754A	30	36	25 MHz Access Switch (requires 3755A switch controller)
	3756A	30	36	90 MHz Switch (requires 3755A)
	3757A	30	36	8.5 MHz Access Switch (requires 3755A)
	3777A	01	01	Telecommunications Channel Selector: up to 30 channels: dc to 110 kHz
	69408	23	27	Multiprogrammer (requires 59500A interface)
	6942A	23	27	Multiprogrammer II (no interface required)
	9411A	*	*	Switch Controller
	9412A	*	*	Modular Switch (requires 9411A switch controller)
	9413A	*	*	VHF Switch (requires 9411A)
	9414A	*	*	Matrix Switch (requires 9411A)
	11713A	28	34	Attenuator/Switch Dirve (controls coax switches and step attenuators)
	12050A/B	24	30	Fiber Optic HP-IB Link
	37201A	17	21	HP-IB Extender: Twisted Pair Pistons
	37203A	NA	NA	HP-IB Extender: Coax and Fiber Optics
	59301A	16	20	ASCII to Parallel Converter: string to 16 characters
	59303A	02	02	Digital to Analog Converter
	59306A	16	20	Relay Actuator for programmable switches, attenuators
	59307A	16	20	VHF Switch two 50 Ohm, bidirectional, dc to 500 MHz
	59308A	09	11	Timing Generator
	59309A	26	32	Digital Clock: month, day, hour, minute, second
	59313A	12	14	Analog to Digital Converter
	59403A	18/19	22/23	HP-IB Common Carrier Interface: RS232C or CCITT V24
	59500A	23	27	Multiprogrammer (6940B) HP-IB Interface
	59501A	06	06	Power Supply Programmer: isolated D to A converter — 10 V dc at 10 mA
Control and Computation	85A/F	21	25	Personal Computer (uses 82937A Interface)
	9815A/S	21	25	Desktop Computer (uses 98135A Interface)
	9825B/T	21	25	Desktop Computer (uses 98034A Interface)
	9835A/B	21	25	Desktop Computer (uses 98034A Interface)
	9845B/T	21	25	Desktop Computer System 45 (uses 98034A Interface)
	9915	21	25	Modular Desktop Computer (uses 82937A Interface
	HP1000 M series	00	00	Computers (2105A, 2108M & 2112M, use 59310B Interface)
	HP1000 E series	00	00	Computers (2109E & 2113E, use 59310B Interface)
	HP1000 F series	00	00	High performance computers (2111F and 2117F use 59310B Interface)
	HP1000 L series	30	36	Low Cost Computer (2103, uses 12009A Interface)
	3075A Option 011	*	*	Desktop Data Capture Terminal (secondary interface for local printer/plotter functions)
	3076A Option 011	*	*	Wall Mounted Data Capture Terminal (secondary interface for local printer/plotter functions)
Cabling	10631A	NA	NA	HP-IB Interconnection Cable: 1 m (3.3 ft)
	10631B	NA	NA	HP-IB Interconnection Cable: 2 m (6.6 ft)
	10631C	NA	NA	HP-IB Interconnection Cable: 4 m (13.2 ft)
	10631D	NA	NA	HP-IB Interconnection Cable: 0.5 m (1.6 ft)
	10833A	NA	NA	HP-IB Interconnection Cable: 1 m (3.3 ft)
	10833B	NA	NA	HP-IB Interconnection Cable: 2 m (6.6 ft)
	10833C	NA	NA	HP-IB Interconnection Cable: 4 m (13.2 ft)
	10833D	NA	NA	HP-IB Interconnection Cable: 0.5 m (1.6 ft)
	10834A	NA	NA	HP-IB Interconnection Cable Adaptor: 2.3 cm (.91 in)

*No typical value, depends on configuration, assume it is set randomly.

NA — No HP-IB address is required, the device is totally transparent or has strictly talk or listen only capabilities.

DESIGNED FOR HP-IB SYSTEMS

Quiz Yourself

Questions regarding the IEEE-488/ANSI MC1.1/IEC 625-1 standards

1. Circle those areas defined by the IEEE-488/ANSI MC1.1 standards
   A. Functional
   B. Electrical
   C. Mechanical
   D. Operational
   E. All of the above

2. Circle those that apply to the IEEE-488/ANSI MC1.1
   A. Asynchronous
   B. Synchronous
   C. Bit-Parallel, Byte-Serial
   D. Bit-Serial, Byte-Parallel
   E. Totally compatible with the IEC 625-1 Part 1 standard

3. On a single contiguous bus (no extension) what are the IEEE-488/ANSI MC1.1 IEC 625-1 limitations as to:
   A. Number of devices on each contiguous bus?__________
   B. Cable length on each contiguous bus?__________
   C. Maximum data transmission rate?__________
   D. Maximum number of active talkers at one time?__________
   E. Maximum number of active listeners at one time?__________
   F. Maximum number of primary (one-byte) addresses available?__________
   G. Maximum number of extended (two-byte) addresses available?__________

4. The logic convention used on the HP-IB is:
   A. Positive-true logic with positive polarity
   B. Negative-true logic with positive polarity
   C. Negative-true logic with negative polarity
   D. Positive-true logic with negative polarity

5. Data is transferred over the data bus as:
   A. 5-bit BAUDOT code
   B. 7-bit ASCII/ISO code
   C. 8-bit ASCII/ISO code
   D. EBCDIC
   E. 8 binary bits typically ASCII/ISO encoded

6. Circle those that apply to the 3-wire handshake sequence:
   A. NRFD and NDAC are wired-or'ed and shared by all active listeners.
   B. Every data-byte transferred over the data bus is hand shook.
   C. The NDAC line is released by a listener *only* after the byte has been acted on by the device (e.g., triggered).
   D. Hewlett-Packard does hold patents on the 3-wire handshake technique.

7. When ATN is low (true) the HP-IB is in which transfer mode?
   A. Command (can send addresses only)
   B. Command (can send commands and addresses)
   C. Data (can send commands and device-dependent data)
   D. Data (can send only device-dependent data)

8. How many bits are required for a complete device address code?
   A. 8
   B. 7
   C. 5
   D. 3

9. In a system without a controller, how are devices addressed?
   A. The talker uses ATN and sends addressed commands over the Data Bus in the command mode.
   B. No addressing is needed.
   C. "Talk Only" and "Listen Only" switches on the devices are set to configure the system (if they exist).

10. What is the difference between DCL and SDC?
    A. DCL can only be sent by a controller whereas SDC can be sent by a talker.
    B. DCL clears all clearable devices while SDC clears only the clearable devices which are active listeners.
    C. DCL takes more steps to implement (longer).

11. To simultaneously trigger a group of devices over the HP-IB, the controller:
    A. Sends GET in the Command mode (ATN true).
    B. Addresses the desired devices to listen and sends GET in the Command mode.
    C. Addresses the desired devices to listen and sends each a device-dependent trigger message.
    D. Either B or C.

12. The LLO multiline command:
    A. Disables all local controls on a device.
    B. Disables the front-panel "local" pushbutton on a device.
    C. Is cleared when the device goes to the local mode of operation by GTL in the Command mode.
    D. Is cleared when REN goes false.
    E. Both B and D above.

13. Which general bus interface management lines can be activated by devices which are talkers or listeners?
    A. ATN, REN, SRQ.
    B. EOI, SRQ.
    C. None.

14. Which general bus interface management lines can be activated by only the system controller?
    A. IFC, ATN, REN
    B. IFC, REN
    C. IFC

15. Can a listen-only device request service?
    A. No, only talkers can request service.
    B. Yes, if the device has only one condition which would require service, it could activate SRQ (no talk function is needed because no status byte is required).
    C. Yes, devices with Parallel Poll capabilities can indicate the need for service if polled by the controller. This differs from the use of the SRQ to request service since the controller initiates the poll.
    D. Both B and C.

16. What are the advantages of serial polling compared to parallel polling?
    A. The device has the initiative of requesting service via the SRQ line.
    B. Serial polling is faster for between 2 and 8 devices.
    C. The nature of the request is obtained concurrently with the identity of a requestor.
    D. A, B, and C.
    E. Both A and C.

17. Black fasteners on the IEEE-488/ANSI MC1.1 mean:
    A. Metric threads but you can mate to silver (English) fasteners.
    B. Metric threads which should not be mated to silver (English) fasteners.
    C. English threads which should not be mated to silver (metric) fasteners.
    D. An RS-232-C type 25-pin connector is used.

18. To achieve the 1 M byte/sec transfer rate, you:
    A. Must have every device turned on and tri-state drivers in every device participating in the transfer.
    B. Must not exceed 15 meters total cable length or one device per meter of cable, whichever is less.
    C. Must limit the capacitive load per device to less than 50 pf.
    D. Must use a bus extension device.

19. The 1978 Revision to the IEEE-488/ANSI MC1.1 Standard:
    A. Was about 90% editorial clarification.
    B. Was a major revision to accommodate modern low-power Schottky technology.
    C. Included a mandatory requirement to mark device's interface capability I.D. codes on the product exterior.
    D. Made it compatible with the IEC 625-1 Standard.

Questions regarding HP-IB system design

1. If you have more than 15 devices (including controller, no bus extension required), you can:
    A. Add an interface until you run out of available I/O slots.
    B. Use extended addressing.
    C. Usually add I/O slots via an I/O expander.
    D. A and/or C as required.

2. To surpass the 20 meter total cable-length restriction you can:
    A. Run 2 interfaces in parallel (add an additional HP-IB interface card).
    B. Use an intra-facility extension technique for requirements below 1000 meters.
    C. Use an inter-facility extension technique for requirements above 1000 meters.

3. An IEEE-488/ANSI MC1.1/IEC 625-1 Bus Analyzer or a general purpose Timing and State Analyzer are useful tools for:
   A. The System Designer when designing HP-IB compatibility into a product, test fixture, or user interface or when adding HP-IB compatibility to a non-HP-IB device (e.g., environmental chamber, BCD device, etc.).
   B. The System Programmer when developing, analyzing, optimizing, or debugging the performance of his systems operating system, specialized device or instrument driver, or other applications where interface characterization may be important.
   C. The System Technician when troubleshooting a system built upon an IEEE-488/ANSI MC1.1/IEC 625-1 interface standard.

4. A Serial Bus Analyzer is a useful tool for:
   A. The System Designer when designing a serial interfacing scheme into his or her HP-IB Instrumentation System..
   B. The System Programmer when communicating over a serial interfacing scheme is his/her HP-IB Instrumentation System.
   C. The System Technician when troubleshooting the serially interfaced portion of an HP-IB Instrumentation System.

5. Circle those system components which could degrade or limit the maximum achievable transfer rate of your interface system:
   A. Resolution or accuracy of a measurement.
   B. Bandwidth of a measurement.
   C. Type of data format chosen on an instrument.
   D. Distribution of computation in the system.
   E. Availability of hardware-controllable features on devices.
   F. The cabling arrangement.
   G. The device's processor, MPU, or state machine logic.
   H. The use of bus extenders.
   I. The data format expected and/or used by the computer.
   J. The Software Language and Language-level chosen.
   K. Choosing IEEE-488/ANSI MC1.1 implementation versus an IEC 625-1 implementation.

Interactive answers to "Quiz Yourself"

Regarding the IEEE-488/ANSI MC1.1/IEC 625-1 standards

1. A, B, C — The operational area is beyond the scope of these standards. The IEC 625-2 Standard does provide Part 2 to its standard "Part 2: Code and Format Conventions" which are recommended practices rather than mandatory specifications for the interface system. Similarily, the IEEE and ANSI have their Recommended Practices.

2. A,C — E is not true due to the different connectors utilized.

3. A. — 15 devices including the controller.
   B. — 20 meters total or 2 meters per device, which ever is less.
   C. — 1 Megabyte/second is the theoretical limit.
   D. — Only 1 device can be an active Talker. When a device is addressed to Talk all other devices automatically Untalk. A universal Untalk command (ASCII/ISO "-") is also provided for convenience.
   E. — Up to 14 devices can listen. This is when the controller is the active Talker.
   F. — There are 31 available primary Talk and Listen addresses. 1-31 are available, 0 is invalid, and 32 is reserved for the Universal Untalk and Universal Unlisten commands.
   G. — There are 961 available extended Talk and Listen addresses. The secondary address byte squares the number of available addresses and has the same restrictions.

4. B. — Negative true logic with a positive polarity is used on all 16 active lines. This allows for an efficient and fast wired-on convention on the shared acceptor handshake lines NRFD, NDAC and also serves to provide a passive "high=false" state on all 16 lines while retaining low-noise susceptibility in the "low=true" state when they appear as low impedances to ground.

5. E. — A full 8 bits is available for sending information. Typically the information is 7 bit ASCII/ISO encoded for integrity (byte parity), an error-rate/efficiency tradeoff. Binary "packing" provides the most efficient encoding (but the most noise susceptibility) where speed is critical.

6. A,B,D — C is not true. That is up to the choice of the device or instrument designer. Newer devices may offer programming modes for holding a handshake sequence by a "busy-line" condition or for fast handshake of listener-dependent data from a talker. Others offer hardware signals to indicate the message has been acted on (e.g., Voltmeter Complete, Data Ready, etc.).

7. B. — Addresses are commands too. Devices respond to commands while in the command mode, this includes DCL, SDC, and GET.

8. B. — Bits 1 through 5 set the devices interface select code but bits 6 and 7 are used to designate between the Talk and Listen ASCII/ISO characters that appear on the Data Bus. (High-level I/O drivers are available in HP computers which require that the user only know the 5-bit interface select code, a number from 1 to 31.)

9. C. — Devices must have a hardware means of being set and cleared of their "Talk Only" or "Listen Only" functions.

10. B — SDC requires addressing steps by definition. This typically can take longer to implement especially since most devices would look for the universal command DCL first while the interface is in the Command mode.

11. B. — The GET addressed command is the only strictly software way to do this.

12. E. — The pushbutton is disabled even if the device or instrument then receives the GTL addressed command and then returns to remote control via its listen address along with the REN uniline command. The only way to clear the LLO condition is by placing the interface in a Local mode with REN false.

13. B.

14. B. — ATN can be activated by any controller to send addressing information.

15. D. Any device can activate the SRQ line. Not all devices can be Serial or Parallel polled. To have Serial poll capabilities a device must have a Talker function to send a status byte. However, the Parallel-Poll technique can inherently request service from the controller regardless of the devices Talker capabilities. This requires that the device has Parallel-Poll capabilities and that the controller does initiate the parallel poll.

16. E. The entire parallel-poll procedure must occur in under 2 micro-seconds, whereas a serial poll would require many steps to guarantee success. A mixture of serial and parallel polling is sometimes used.

17. B. Watch out for those silver fasteners!

18. A,B,C.

19. A Most of the changes constituted addendum (clarification and expansion) and some errata (anomolies).

Regarding HP-IB system design

1. D. Again, more than 15 devices constitutes a fairly extensive system. You should find your I/O slot and expansion capabilities adequate in most quality desktop or minicomputers.

2. B. A should never be attempted. Although C enables you to put up to 40 meters between devices, you have not surpassed the 20 meters total cable-length restriction.

3. A,B,C. Whether you're designing, programming, or troubleshooting an HP-IB based measurement system or subsystem, a dedicated or general-purpose bus analyzer is a useful tool. They are especially useful when characterizing the handshake times of HP-IB compatible system components as part of an overall throughput analysis.

4. A,B,C. If your system occupies the role of a measurement node in a larger distributed system environment, you may have a need for a serial interface for one or more of the following reasons:
   - Bus extension (INTRA FACILITY and INTER-FACILITY)
   - Adding RS-232-C/CCITT V24 compatible but non-IEEE-488/ANSI MC1.1/IEC 625-1 components.
   - Communicating over a noisy environment (transformers, arc-welding, inductive power systems, etc.).
   - Terminal Emulation (ASYNCHRONOUS).
   - Remote Job Entry (RJE) (SYNCHRONOUS).
   - Factory Data Collection over a Factory Data Link (FDL).
   - Other Data Communications and Distributed Systems Applications.

   A serial link analyzer is an important design, programming, and service tool for these applications.

5. A-J K is the only system component which would not limit the transfer rate of the interface system directly. Whether you choose an IEEE-488/ANSI MC1.1 or IEC 625-1 implementation the theoretical maximum rate on your interface would be the same.

Glossary of HP-IB related terms

"To help you interpret the Standards and other Information Sources"

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 — Control line (Attention) establishes between the "Command Mode" and "Data Mode" of operation on the HP-IB.

BIDIRECTIONAL BUS — A bus used by any individual device for two-way transmission of messages, that is, both input and output.

BIT — The smallest part of an HP-IB character (Byte) which contains intelligible information. A Binary Digit.

BIT-PARALLEL — Refers to a set of concurrent data bits present on a like number of signal lines used to carry information. Bit-parallel data bits may be acted upon concurrently as a group (byte) or independently as individual data bits.

BUS — A signal line or a set of signal lines used by an interface system to which a number of devices are connected and over which messages are carried.

BUS COMMANDS — A group of ASCII Codes which initiate certain types of operation in devices 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.

BYTE — Character sent over the DIO lines, normally consisting of eight bits.

BYTE-SERIAL — A sequence of bit-parallel data bytes used to carry information over a common bus.

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

COMPATIBILITY — The degree to which devices may be interconnected and used, without modification.

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 predefined 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.

DRT — Device Reference Table, on HP 1000 symbol table which equates a Logical Unit Number to an EQT entry.

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.

EQT Equipment Table, an HP 1000 symbol table which equates a specific EQT number to a driver, select code, or other I/O information.

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

EXTENDED TALKER — An instrument which can use 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.

HIGH STATE — The relatively more positive signal level used to assert a specific message content associated with one or two binary logis states.

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

IBLU — (Integer) Bus Logical Unit. An HP 1000 mnemonic for the LU of the HP-IB interface.

IDLU — (Integer) Device Logical Unit. An HP 1000 mnemonic for the LU of the HP-IB device.

IFC — General Interface Management Line "Interface Clear" used by the system controller to halt all current operations on the bus, unaddress all other devices, and disable Serial Poll.

INTERFACE — A common boundary between a considered system and another system, or between parts of a system, through which information is conveyed.

INTERFACE SYSTEM — The device-independent mechanical, electrical, and functional elements of an interface necessary to effect communication among a set of devices. Cables, connector, driver and receiver circuits, signal line descriptions, timing and control conventions, and functional logic circuits are typical interface system elements.

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

LOCAL CONTROL — A method whereby a device is programmable by means of its local (front or rear panel) controls in order to enable the device to perform different tasks. (Also referred to as manual control.)

LOCAL LOCKOUT — An HP-IB multiline universal command which disables the (ASCII character "OCI" Octal 021) return-to-local control (pushbutton) on a device (prevents user from leaving remote control other than cycling power). Clearing the REN line of the HP-IB restores local control and re-enables the return-to-local pushbutton on every HP-IB device.

LOW STATE — The relatively less positive signal level used to assert a specific message content associated with one of two binary logic states.

LU — Logical Unit.

NDAC — Mnemonic referring to the control line "Not Data 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 multiline messages consisting of universal commands, addressed commands, and device addresses sent by a CONTROLLER in the DATA MODE (ATN).

PROGRAMMABLE — That characteristic of a device that makes it capable of accepting data to alter the state of its internal circuitry to perform a specific task(s).

PROGRAMMABLE MEASURING APPARATUS — A measuring apparatus that performs specified operations on command from the system and, may transmit the results of the measurement(s) to the system.

REMOTE CONTROL — A method whereby a device is programmable via its electrical interface connection in order to enable the device to perform different tasks.

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 multiline messages used to increase the command address length of extended talkers and listeners to two bytes.

SELECTIVE DEVICE CLEAR — ASCII character "EOT" (Octal 004) which returns selected devices 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).

SIGNAL — The physical representation of information.

SIGNAL LEVEL — The magnitude of signal compared to an arbitrary reference magnitude (voltage in the case of this standard).

SIGNAL LINE — One of a set of signal conductors in an interface system used to transfer messages among interconnected devices.

SIGNAL PARAMETER — That parameter of an electrical quantity whose values or sequences of values convey information.

SYSTEM — A set of interconnected elements constituted to achieve a given objective by performing a specified function.

TERMINAL UNIT — An apparatus that terminates the considered interface system and by means of which a connection (and translation, if required) is made between the considered interface system and another external interface system.

UNIDIRECTIONAL BUS — A bus used by an individual device for one-way transmission of messages only, that is, either input only or output only.

WORD — A group of "characters" treated as a unit and given a single location in memory (organization defines the length of a computer "word"). HP computers typically use a word oriented memory with 16-bit (2 byte) words.

Hewlett-Packard HP-IB Bibliography

General HP-IB

PUBLICATION #	DESCRIPTION
AN-201-4	Performance Evaluation of HP-IB using RTE Operating Systems, Revised.
AN-201-6	Desktop-Minicomputer Communications
AN-201-7	High-performance software for the HP 3455A/3495A Subsystem
AN-201-8	The Use of Device Subroutines with HP-1000 Computers
AN-201-9	Techniques for Extending the Distance Between HP-IB Instruments and Controllers
AN-290	Practical Temperature Measurements (Thermocouples, RTD's, Thermistors, IC Transducers).
AN-401-1	HP-1000 M,E,F/HP-IB Programming Procedures (P/N 5953-2800). First of a continuing series.
AN-401	Index for AN 401 Series HP 1000/HP-IB Programming, Programming Notes
03052-90032	Pre-study Manual: 9825
03052-90205	Pre-study Package: 9835A
03052-90230	Pre-study Package: 9845A
03054-91501	Introductory Guide: 85
03054-92501	Introductory Guide: 9825
03054-93501	Introductory Guide: 9835
03054-94501	Introductory Guide: 9845
5952-0056	Hewlett Packard Measurement and Computation Help Improve Productivity
5952-0070	HP-IB and the 9835A
5952-0078	HP-IB Brochure (English)

PUBLICATION #	DESCRIPTION
5952-8834	Precision Instrumentation for Data Acquisition.
5952-8799	Financial Justification: Circuit Test Systems
5952-90056	HP-IB with the 9825 Calculator
5953-0904	Data Acquisition and Control with the System 45
5953-0979D	System 35 Technical Supplement: Assembly Language
5953-0985	I/O Supplement for the System 35
5953-1001	HP Enhanced BASIC
5953-0786	Calculators User's Club
5953-1048	Desktop Computer Applications in Industry
5953-1085	Consumables
5953-1050	Peripherals
5953-1087	Quality
5953-1083	BASIC User's Club
5953-1090	Data Acquisition and Control
5953-1094	HP 6940/9825 Automatic Test Measurement, and Control System
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5953-3318	HP Computer Systems Support Services Data Book
5953-3866D	Do Your Own System Design in Weeks, Instead of Months
5953-4212	DS/1000 Applications Brochure
5953-4224	Data Cap/1000
5953-4227	Fiber Optic HP-IB Link Product
5953-4247	ATS/1000 Integration Services Configuration Guide
5953-4513	System 35/45 Programming Language
5955-0961	HP-IB Instruments
09825-90060	Interfacing Concepts and the 9825A

PUBLICATION #	DESCRIPTION
09835-90600	BASIC Language Interfacing Concepts
12009-90001	HP 12009A HP-IB Interface Reference Manual (for HP 1000 L-Series)
59300-90005	HP-IB Programming Hints for Selected Instruments: 9825A
59310-90064	The HP-IB in HP 1000 Computer Systems Users Manual
59310-90063	RTE Driver DVR 37 for HP 59310B Interface Bus Programming & Operation Manual
59310-90068	59310B Bus Input/Output Interface Kit Operation & Service Manual
59401-90030	Condensed Description of the Hewlett Packard Interface Bus
92070-90011	RTE-L Driver Reference Manual (for HP 1000 L-Series)

Hewlett-Packard HP-IB Bibliography

HP-IB Device/System Model Number

MODEL NUMBER	DESCRIPTION	DOCUMENT
11713A	Attenuator/ Switch Driver	Programming Note: Introductory Operating Guide for the 11713A Attenuator/Switch Driver with the 9825A Desktop Computer (5952-8215) Programming Note: Introductory Operating Guide for the 11713A Attenuator/Switch Driver with the 9835 Desktop Computer (5952-8231)
1350A	Graphics Translator	AN 271-1 Instrumentation Graphics Adding soft copy graphics to 9825A based HP-IB systems using the model 1350A Graphic Translator 10184A Software Library Contains binary routine to make 1350A look like 9872A (HP-GL)
1615A	Logic Analyzer	1615A/9825A Introductory Operating Guide
2240A	Measurement & Control Processor	HP 2240A Measurement and Control Processor —Technical Data (5952-8542) HP 2240A Measurement and Control Processor — Extended Performance Option Technical Data Supplement (5953-3091) HP 2240A Measurement and Control Processor — Measurement and Control Examples App Note 224-1 (5952-8547)
2631A	Matrix Printer	Installation Note: HP 2631A Printer, HP 9825A Calculator (09825-9007)
3042A	Network Analyzer	AN 205-1 Network Analysis with HP-IB Systems Low Frequency Amplitude Considerations of 3042 Systems AN 205-2 Network Analysis with HP-IB Systems Sonar Transducer Calibration
3052A	Automatic Data Acquisition System	Technical Data Sheet, Nov. 1979 (5952-8822) gives useful system throughput information

MODEL NUMBER	DESCRIPTION	DOCUMENT
3054A	Automatic Data Acquisition/ Control System (See General HP-IB)	Pre-Study Packages Technical Data Sheet, May 1980, (5952-8825) useful system throughput information Introductory Guides, Ap-Note, etc. (See General HP-IB)
3325A	Synthesizer/ Function Generator	Application Guide for the 3325A Synthesizer/ Function Generator (P/N 5952-8771) AN-401-13 3325 Function Generator/HP 1000 Computer (P/N 5953-2812)
3335A	Synthesizer/ Level Generator	9825A/SLM User's Guide (P/N 5952-3222)
3336A/B/C	Synthesizer/ Level Generator	User's Guide: Using the HP 3586A, B, & C Selective Level Meter and HP 3336A, B, & C Synthesizer/Level Generator (5952-8821)
3437A	System Voltmeter	HP-IB programming hints for selected instruments, 9825A (P/N 59300-90005) AN 401-10 3437A Digital Voltmeter/HP 1000 M,E,F Computer (P/N 5953-2809) Introductory Operating Guide (P/N)
3438A	Digital Multimeter	HP-IB programming hints for selected instruments, 9825A (P/N 59300-9000) AN-401-6 3438A Digital Multimeter/HP 1000 M,E,F Computer (P/N 5953-2805)
3455A	Digital Voltmeter	HP-IB Programming Hints for selected instruments, 9825A (P/N 59300-90005) AN 401-7 3455A Digital Multimeter/ HP 1000 M,E,F Computer (P/N 5953-2806)
3456A	Digital Voltmeter	Introductory Users Guide, April, 1980 (P/N 03456-90002) Technical Data Sheet, May 1980 (P/N 5952-8830D) Has useful system throughput information Introductory Operating Guide (P/N 5952-2911)
3497A	Data Acquisition/ Control Unit	AN-401-22 3497A Data Acquisition/Control Unit/HP 1000 M,E,F,L Computer (P/N 5953-2821) Introductory User's Guide, April, 1980, (P/N 03497-90001) Quick Reference Guide (03497-90002)

MODEL NUMBER	DESCRIPTION	DOCUMENT
3495A	Scanner	HP-IB Programming Hints for selected instruments, 9825A (P/N 59300-90005) AN-401-11 3495A Scanner/HP 1000 Computer (P/N 5953-2810)
3571A	Spectrum Analyzer	HP-IB Programming Hints for selected instruments, 9825A (P/N 59300-90005)
3582A	Spectrum Analyzer	Understanding the 3582A Spectrum Analyzer (P/N 5952-8773) AN-245-1 Signal Averaging with the HP 3582A Spectrum Analyzer AN-245-2 Measuring the Coherence Function with the HP 3582A Spectrum Analyzer AN-245-3 Third Octave Analysis with the HP-3582A Spectrum Analyzer AN-245-4 Accessing the 3582A Memory with HP-IB AN-245-5 Log Sweep with the HP 3582A Spectrum Analyzer AN-401-12 3582A Spectrum Analyzer/ HP 1000 M,E,F Computer (P/N 5953-2811)
3585A	Spectrum Analyzer	AN-246 Using the HP 3585A Spectrum Analyzer with the HP 9825A Computing Controller
3586A/B/C	Selective Level Meter	Using the HP 3586A, B & C Selective Level Meter and HP 3336A, B & C Synthesizer/Level Generator (5952-8821)
3745/47/A/B	Selective Level Measuring Set	9825A/SLMS User's Guide (P/N 5952-3222)
3754/55A	Access Switch/ Switch Controller	9825A/SLMS User's Guide (P/N 5952-3222)
432C	Power Meter	AN-196-1 Automated Power Measurements Using the 432C Power Meter Including Waveguide and Fiber Optic Measurements (Note: 432C utilizes the 432C-K01 decidated interface and no HP-IB)
436A	Microwave Power Meter	AN-401-16 436A Microwave Power Meter/HP 1000 M,E,F Computer (P/N 5953-2815)
42624	Digital LCR Meter	AN-401-14 4262A Digital LCR Meter/ HP 1000 M,E,F Computer (P/N 5953-2813)

MODEL NUMBER	DESCRIPTION	DOCUMENT
4943A	Transmission Impairment Measuring Set	Operating Note (shipped w/instrument) (P/N 04943-90026)
4944A	Transmission Impairment Measuring Set	Operating Note (shipped w/instrument) (P/N 04944-90009)
5150A	Thermal Printer	9825A/SLMS User's Guide (P/N 5952-3222)
5312A	Universal Frequency Counter	AN 181-2, Data Acquisition with the 500B
5328A	Universal Frequency Counter	Introductory Operating Guide (for 5328A Universal Counter with 9825A Controller) (P/N 02-5952-7569)
		Quick Reference Guide for 5328A Universal Counter (P/N 02-5952-7596)
		Technical Note: 5328A Universal Counter, Programming Via the Hewlett-Packard Interface Bus (P/N 02-5952-7440)
		AN-287-1 Waveform Analysis using the 5328A Universal Frequency Counter
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5335A	Universal Frequency Counter	Introductory Operating Guide (for 5335A Universal Counter with 9835A Controller) (P/N 02-5952-7596)
5340A	Microwave Frequency Counter	Introductory Guide for the 5340A Microwave Counter with the 9825A Controller (02-5952-7556)
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5342A	Microwave Frequency Counter	Introductory Operating Guide (for 5342A Microwave Counter with 9825A Controller) (P/N 02-5952-7533)
		AN-401-4 5342A Microwave Counter/HP 1000 M,E,F Computer (P/N 5953-2803)

MODEL NUMBER	DESCRIPTION	DOCUMENT
5345A/55/56	Frequency Counter	AN-287-2 Frequency Profile using an HP 5345A Electronic Frequency Counter and an HP 5359A Time Synthesizer
		AN-292-1 Application Guide to the 5355/56 Automatic Frequency Converter
		Quick Reference Guide for 5345A Electronic Counter (P/N 02-5952-7547)
		AN-401-3 5345A Counter/HP 1000 M,E,F Computer (P/N 5953-2802)
		Programming Note: Introductory Programming Guide (for 5345A Electronic Counter with 9825A Controller) (P/N 02-5952-7538)
5345A/44/56	Frequency Counter	Introductory Operating Guide for the 5355A Automatic Frequency Converter with the 9825A Controller (02-5952-7551)
		HP-IB Programming Hints for selected instruments, 9825A (P/N 59300-90005)
5355A	Automatic Frequency Converter	Introductory Operating Guide for the 5355A Automatic Frequency Converter with the 9825A Controller (02-5952-7551)
5359A	Time Synthesizer	Introductory Operating Guide for the 5359A Time Synthesizer with the 9825A Controller (5952-7565)
		AN-287-2 Frequency Profile Using an HP 5345A Electronic Frequency Counter and an HP 5359A Time Synthesizer
		AN-287-3 Frequency Profile Using an HP 5370A Universal Time Interval Counter and an HP 5359A Time Synthesizer
5363B	Time Interval Probes	AN-191-5 Measurement of Propagation delays using the 5370A Time Interval Counter and 5363B Time Interval Probes (Using 9825A)
5370A	Universal Time Interval Counter	Introductory Operating Guide for the 5370A Universal Counter with the 9825A Controller (02-5952-7555)
		AN-287-3 Frequency Profile using an HP 5370A Universal Time Interval Counter and an HP 5359A Time Synthesizer
		AN-191-5 Measurement of Propagation delays using the 5370A Time Interval Counter and 5363B Time Interval Probes (using 9825A)

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5390A	Frequency Stability Analyzer	AN-225 Measuring Phase Spectral Density of Synthesized Signal Sources Exhibiting f_0 and f_{-1} Noise Characteristics with the 5390A Frequency Stability Analyzer
		AN-225-1 Measurement Considerations when using the 5390A opt 010
59304A	Numeric Display	HP-IB Programming Hints for selected instruments, 9825A (P/N 59300-90005)
59306A	Universal Switch	HP-IB Programming Hints for selected instruments, 9825A (P/N 59300-9005)
		AN-401-18 59306A Relay Actuator/HP 1000 M,E,F Computer (P/N 5953-2817)
59307A	VHF Switch	HP-IB Programming Hints for selected instruments, 9825A (P/N 59300-90005)
		AN-401-2 VHF Swtich/HP 1000 M,E,F Computer (P/N 5953-2801)
59308A	Timing Generator	HP-IB Programming Hints for selected instruments, 9825A (P/N 59300-90005)
59309A	Digital Clock	HP-IB Programming Hints for selected instruments, 9825A (P/N 59300-90005)
		AN-401-8 Digital Clock/HP 1000 M,E,F Computer (P/N 5953-2807)
59310B	HP 1000, M,E,F Interface Card	The HP-IB in HP 1000 Computer Systems User's Manual (P/N 59310-90064)
59403A	Common Carrier Interface	HP-IB Programming Hints for selected instruments, 9825A (P/N 59300-90009)
		9825A/SLMS User's Guide (P/N 5952-3222)
59501A	Power Supply Programmer	HP-IB / Power Supply Interface Guide (P/N 5952-3990)
		HP-IB Programming Hints for selected instruments, 9825A (P/N 59300-90005)
6002A	Power Supply (option 001)	HP-IB / Power Supply Interface Guide (P/N 5952-3990)
		AN-401-9 6002A Power Supply/HP 1000 M,E,F Computer (P/N 5953-2808)

MODEL NUMBER	DESCRIPTION	DOCUMENT
6940B	Multiprogrammer	6940B Multiprogrammer User's Guide for the HP 9825A (P/N 59500-90005)
		AN-282-1 6940B Multiprogrammer System Throughput Analysis for Multiprogrammer Systems using the 9825A Desktop Computer (P/N 5952-4017)
		14556A Software Library
6942A	Multiprogrammer	6942A Multiprogrammer — Technical Data (5952-4034 D)
		Multiprogrammer User's Guide (06942-90003)
		AN-401-21 6942A Multiprogrammer II/HP 1000 M,E,F Computer (P/N 5953-2820)
7225A	Plotter	7225/17600 Plotter Demo Tape/9825 (P/N 07225-18002 Rev. A)
		7225/17601 Plotter Demo Tape/9825 (P/N 09872-18001 Rev. C)
		7225/17601 Plotter Demo Tape/9835 (P/N 09872-18002 Rev. B)
		7225/17601 Plotter Demo Tape/9845 (P/N 09872-18003 Rev. B)
		7225/17603 Plotter Demo Tape/9845 (P/N 07220-18001 Rev. A)
7245A	Printer/Plotter	7245A/B Plotter/Printer Demo Tape/9825 (P/N 07245-18001 Rev. B)
		7245A/B Plotter/Printer Demo Tape/9835/9845 (P/N 07245-18002 Rev. B)
7310A	Graphics Printer	7310A Graphics Printer Demo Tape/9835 (P/N 07310-18002 Rev. A)
8165A	Programmable Signal Source	AN-298 A Stimulus for Automatic Test
8410B	Microwave Network Analyzer	AN-221 Semi-Automatic Measurements Using the 8410B Microwave Network Analyzer and the 9825A
8566A	Microwave Spectrum Analyzer	8566A Spectrum Analyzer Remote Operation (P/N 08566-90003)
		85861A Software Pac for 8582A Automatic Spectrum Analyzer (8566A/9825T/HP-IB 9866A), Data Sheet for Software (5952-9352)

MODEL NUMBER	DESCRIPTION	DOCUMENT
8568A	RF Spectrum Analyzer	AN-270-1 An Example of Automatic Measurement of Conducted EMI with the HP 8568A Spectrum Analyzer
		AN-207-2 Automated Noise Sideband Measurements using the 8568A Spectrum Analyzer "Implementing AN-270-2 with the HP 8568A and HP 9825A" Application Note (5952-9350) Programming Note (5952-9351) Programming Note & Tape (08568-60120)
		85860A Software Pac for 8581A Automatic Spectrum Analyzer (8568A/9825T/HP-IB/9866B), Data Sheet for Software (5952-9283)
		8568A Spectrum Analyzer Remote Operating (P/N 08568-90003)
8620C	Sweep Oscillator	AN-187-5 Calculator control of the 8260C using the Hewlett Packard Interface Bus
		AN-401-17 8620A Sweep Oscillator/HP 1000 M,E,F Computer (P/N 5953-2816)
8660A/B/C	Signal Generator	AN-164-2 Calculator Control of the 8660A/B/C Synthesized Signal Generator (optional HP-IB interface)
		AN-401-19 8660C Synthesized Signal Generator/HP 1000 M,E,F Computer (P/N 5953-2819)
8662A	Synthesized Signal Generator	AN-283-2 External Frequency Doubling of the 8662A Synthesized Signal Generator
8671A	Microwave Frequency Synthesizer	AN-218-2 Obtaining Millihertz Resolution 8671A & 8672A
8672A	Synthesized Signal Generator	Introductory Operating Guide for the 8672A Synthesized Signal Generator with the 9825A Desktop Computer (5952-8221)
		AN-401-15 8672A Synthesized Signal Generator/HP 1000 Computer (P/N 5953-2814)
8754A	Network Analyzer	AN-294 Semi-Automatic RF Network Measurements Using the HP 8754A Network Analyzer and the HP 9825A Desktop Computer
8901A	Modulation Analyzer	AN-286-1 Application and Operation of the 8901A Modulation Analyzer

MODEL NUMBER	DESCRIPTION	DOCUMENT
9871A	Printer Plotter	HP-IB Programming Hints for selected instruments, 9825A (P/N 59300-90005) AN-401-20 9871A Character Impact Printer/HP 1000 M,E,F Computer (P/N 5953-2819)
85860	Automatic Spectrum Analyzer (8566A:9825B)	85861-10001 Rev. A Tape 85861-10002 Rev. A Tape (9825T) 85860 Operating & Programming Manual (P/N 85860-90001)
85861	Automatic Spectrum Analyzer (8568A:9825B)	85860-10001 Rev. A Tape 85860-10002 Rev. A Tape (9825T) 85861 Operating & Programming Manual (P/N 85861-90001)
9872A/B/S	Printer Plotter	Four Color Plotter Demo Tape 19825 (P/N 09872-18001 Rev. C)
9872A/B/S	Printer Plotter	Four Color Plotter Demo Tape/9835 (P/N 09872-18002 Rev. B)
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Hewlett-Packard HP-IB verification programs

There are many verifications programs available to check out Hewlett-Packard HP-IB products. The attached list is up-to-date for the fall of 1980.

Since programs are added on a regular basis, contact the closest Hewlett-Packard office if you do not see the program you are interested in.

HP-IB verification programs

MODEL		TAPE	PROGRAM DOCUMENTATION
59301A	ASCII/Parallel Converter	59300-10001 (9825A)	Service Note 59301A-2
59303A	D to A Converter		Service Note 59303A-1
59304A	Numeric Display		Service Note 59304A-1
59306A	Relay Actuator		Service Note 59306A-4
59307A	VHF Switch		Service Note 59307A-3
59308A	Timing Generator		Service Note 59308A-1
59309A	Digital Clock		Service Note 59309A-3
59313A	A to D Converter		59313A Manual 59313-91999
5328A	Universal Counter (Opt. 011)		Service Note 5328A-17
5340A	Freq. Counter (Opt. 011)		Service Note 5340A-11
5341A	Freq. Counter (Opt. 011)		5341A Manual 05341-90005
5342A			5342A Manual 05342-90004
5345A	Electronic Counter (Opt. 011)		Service Note 5345A-9
5359A	Time Synthesizer		5359A Manual 05345-90001
8672A	Synth. Sig. Gen.	11712-10001 (9830A)	Kit Manual 11712-90001
		11712-10002 (9825A)	
8568A	Spectrum A	85860-10001 (Rev. A/02 Rev. A)	
		08568-10001 (9825A)	8568A Manual 08568-90011
8507A	Network Analyzer	85030-10002 (9830A)	8507A Manual 85030-90001
			8507A Manual 08507-90005
8507A	Network Analyzer	85030-10007 (9825A)	8507B Manual 85030-90005
			8507B Manual 08507-90022
3042A	Network Analyzer	03042-90211 (9825A)	3042A Manual 03042-90204
3045A	Spectrum Analyzer	03045-10001 (9825A)	3045A Manual 03045-90203
3050B	Voltmeter System	03050-90230 (9825A)	3050B Manual 03050-90223
		03050-90212 (9830A)	3050B Manual 03050-90200
3052A	Verification (9825)	03052-90011	3052 Manual
3052A	Verification (9835A)	03052-10002	3052 Manual
3052A	Verification (9835B)	03052-10004	3052 Manual
3052A	Verification (9845B)	03052-10008	3052 Manual
3054A	Verification (9835A)	03054-10002	3054 Manual
3054A	Verification (9845B)	03054-10005	3054 Manual
3335A	Frequency Synthesizer (9825)	03335-10001	3335A Manual
3437A	System DVM	03437-10001 (9825A)	3952A Manual 03052-90004
3455A	System DVM	03455-10001 (9830A)	3052A Manual 03052-90004
		03455-10002 (9825A)	3052A Manual 03052-90004
3495A	Scanner	03495-10001 (9830A)	3495A Manual 03495-90012
		03495-10002 (9825A)	3495A Manual 03495-90012
436A	Power Meter	00436-10006 (9830A)	436A Manual 00436-90012
		00436-10007 (9825A)	Service Note 436A-2
3582A	Spectrum Analyzer	03582-10002 (9825)	
3585A	Spectrum Analyzer	03585-10001 (9825)	
3745A	Selective Level Measuring Set (25 MH)		3745A Manual 03745-90006
3745B	Selective Level Measuring Set (25 MH)		3745B Manual 03745-90007
3747A	Selective Level Measuring Set (90 MH)		3747A Manual 03747-90001

MODEL		TAPE	PROGRAM DOCUMENTATION
3747B	Selective Level Measuring Set (90 MH)		3747B Manual 03747-90003
3745A and 3747A/B	SLMS User's Guide		5952-3215 (9830)
	SLMS User's Guide		5952-3222 (9825)
3755A	Switch Controller		3755A Manual 03755-90000
3771A	Dateline Analyzer (CCITT)		3771A Manual 03771-90009
3771B	Dateline Analyzer (BELL)		3771B Manual 03771-90010
3777A	HP-IB Controller Channel Selector		3777A Manual 03777-90000
3779A	Primary Multiplex Analyzer (CEPT)		3779A Manual 03779-90001
3779B	Primary Multiplex Analyzer (BELL)		3779B Manual 03779-90002
37201A	HP-IB Extender		37201A Manual 37201-90000
6940B	Multiprogrammer	14551-13001 Rev. B (for 9825A)	Supplied with tape
6941B	Multiprogrammer Extender		Supplied with tape
59500A	Multiprogrammer HP-IB Interface		Supplied with tape
69321B	Multiprogrammer DA Voltage Converter		Supplied with tape
69XXX	Multiprogrammer Plug-In Cards		Supplied with tape
59501A	D/A Converter		Service Note 59501A-1
8620C	Sweep Oscillators and Plug-Ins (Contact Local Sales Office for Tape and Documentation)		Supplied with tape
86210		Included in 8620C tape.	
86220			
86222			
86230			
86235			
86240			
86241			
86242			
86245			
86250			
86260			
86290			
86320			
86330			
86331			
86341			
86342			
86350			
86351			
86352			
All special modules			
8501A	Storage Normalizer	No tape listing	8501A Manual 08501-90018 (9825, 9830)
7225A/ 17601 9872B/S	Graphics Plotter	09872-18001, Rev. C (9825)	
7225A/ 17601 9872B/S	Graphics Plotter	09872-18002, Rev. B (9835)	
7225A/ 17601 9872B/S	Graphics Plotter	09872-18003, Rev. B (9845)	

MODEL		TAPE	PROGRAM DOCUMENTATION
7245A (will also work on B)	Plotter/Printer	07245-18001, Rev. B (9825)	
7245A (designed for A, works on B also)	Plotter/Printer	07245-18002, Rev. B (9835 and 9845)	
7225A/ 17600	Graphics Plotter	07225-18002, Rev. A (9825)	
7225A/ 17600	Graphics Plotter	07225-18003, Rev. A (9815)	
7310A	Graphics Plotter	07310-18001, Rev. A (2647)	
7310A	Graphics Plotter	07310-18002, Rev. A (9835)	
7221 (S or B)	Four-Color Graphics Plotter	7221-18010 (264X)	
7225A/ 17603, 7220A/S	Graphics Plotter	7220-18001, Rev. A (9825)	
8160A	Prog. Pulse Gen.	08160-39910 (9825) (Verification and calibration software provided with tape)	

Appendix A

ASCII/ISO & IEEE Code Chart

ASCII/ISO Mnemonic Descriptions

NUL	Null	DLE	Data Link Escape
SOH	Start of Heading	DC1	Device Control 1
STX	Start of Text	DC2	Device Control 2
ETX	End of Text	DC3	Device Control 3
EOT	End of Transmission	DC4	Device Control 4 (Stop)
ENQ	Enquiry	NAK	Negative Acknowledge
ACK	Acknowledge	SYN	Synchronous Idle
BEL	Bell (audible or attention signal)	ETB	End of Transmission Block
BS	Backspace	CAN	Cancel
HT	Horizontal Tabulation (punched card skip)	EM	End of Medium
LF	Line Feed	SUB	Substitute
VT	Vertical Tabulation	ESC	Escape
FF	Form Feed	FS	File Separator
CR	Carriage Return	GS	Group Separator
SO	Shift Out	RS	Record Separator
SI	Shift In	US	Unit Separator
		DEL	Delete

American National Standard Code for Information Interchange (ASCII 68).

International Standard Organization

IEEE Mnemonic Descriptions

GTL	Go To Local
SDC	Selected Device Clear
PPC	Parallel Poll Clear
GET	Group Execute Trigger
TCT	Tak ConTrol
LLD	Local LockOut
DCL	Device CLear
PPU	Parallel Poll Unconfigure
SPE	Serial Poll Enable
SPD	Serial Poll Disable

ASCII/ISO & IEEE CODE CHART

B7 B6 B5 BITS / B4 B3 B2 B1	Ø Ø Ø	Ø Ø 1	Ø 1 Ø	Ø 1 1	1 Ø Ø	1 Ø 1	1 1 Ø	1 1 1
	CONTROL		NUMBERS SYMBOLS		UPPER CASE		LOWER CASE	
Ø Ø Ø Ø	0 NUL 0 0	20 DLE 10 16	40 SP 20 32	60 0 30 48	100 @ 40 64	120 P 50 80	140 ` 60 96	160 p 70 112
Ø Ø Ø 1	1 GTL SOH 1 1	21 LLO DC1 11 17	41 ! 21 33	61 1 31 49	101 A 41 65	121 Q 51 81	141 a 61 97	161 q 71 113
Ø Ø 1 Ø	2 STX 2 2	22 DC2 12 18	42 " 22 34	62 2 32 50	102 B 42 66	122 R 52 82	142 b 62 98	162 r 72 114
Ø Ø 1 1	3 ETX 3 3	23 DC3 13 19	43 # 23 35	63 3 33 51	103 C 43 67	123 S 53 83	143 c 63 99	163 s 73 115
Ø 1 Ø Ø	4 SDC EOT 4 4	24 DCL DC4 14 20	44 $ 24 36	64 4 34 52	104 D 44 68	124 T 54 84	144 d 64 100	164 t 74 116
Ø 1 Ø 1	5 PPC ENQ 5 5	25 PPU NAK 15 21	45 % 25 37	65 5 35 53	105 E 45 69	125 U 55 85	145 e 65 101	165 u 75 117
Ø 1 1 Ø	6 ACK 6 6	26 SYN 16 22	46 & 26 38	66 6 36 54	106 F 46 70	126 V 56 86	146 f 66 102	166 v 76 118
Ø 1 1 1	7 BEL 7 7	27 ETB 17 23	47 ' 27 39	67 7 37 55	107 G 47 71	127 W 57 87	147 g 67 103	167 w 77 119
1 Ø Ø Ø	10 GET BS 8 8	30 SPE CAN 18 24	50 (28 40	70 8 38 56	110 H 48 72	130 X 58 88	150 h 68 104	170 x 78 120
1 Ø Ø 1	11 TCT HT 9 9	31 SPD EM 19 25	51) 29 41	71 9 39 57	111 I 49 73	131 Y 59 89	151 i 69 105	171 y 79 121
1 Ø 1 Ø	12 LF A 10	32 SUB 1A 26	52 * 2A 42	72 : 3A 58	112 J 4A 74	132 Z 5A 90	152 j 6A 106	172 z 7A 122
1 Ø 1 1	13 VT B 11	33 ESC 1B 27	53 + 2B 43	73 ; 3B 59	113 K 4B 75	133 [5B 91	153 k 6B 107	173 { 7B 123
1 1 Ø Ø	14 FF C 12	34 FS 1C 28	54 , 2C 44	74 < 3C 60	114 L 4C 76	134 \ 5C 92	154 l 6C 108	174 ¦ 7C 124
1 1 Ø 1	15 CR D 13	35 GS 1D 29	55 – 2D 45	75 = 3D 61	115 M 4D 77	135] 5D 93	155 m 6D 109	175 } 7D 125
1 1 1 Ø	16 SO E 14	36 RS 1E 30	56 . 2E 46	76 > 3E 62	116 N 4E 78	136 Λ 5E 94	156 n 6E 110	176 ~ 7E 126
1 1 1 1	17 SI F 15	37 US 1F 31	57 / 2F 47	77 UNL ? 3F 63	117 O 4F 79	137 UNT — 5F 95	157 o 6F 111	177 RUBOUT (DEL) 7F 127
	ADDRESSED COMMANDS	UNIVERSAL COMMANDS	LISTEN ADDRESSES		TALK ADDRESSES		SECONDARY ADDRESSES OR COMMANDS	

KEY

octal	25 PPU	Message Mnemonic
	NAK	ASCII/ISO character
hex	15 21	decimal

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