

Bench Testing A "Bus" Instrument

Hewlett-Packard calls it HP-IB; other manufacturers call it GPIB; and others yet call it IEEE-488. Whatever the name, the concept is the same - remote programming capabilities via an IEEE-488 Standard Digital Interface.

by Jim Bechtold, Editor

More and more manufacturers are producing programmable bench instruments that follow the IEEE-488 standard. There are also many books written on bus protocol, structure, and how to write programs that will exercise systems and instruments to perform various kinds of measurements. However, there is not much information for the bench technician on how to troubleshoot the interface concept or the remote programming capabilities of an instrument attached to the bus. This article has been written using the HP 59401A Bus System Analyzer (Figure 1) as a troubleshooting tool to help fulfill those needs.

It is assumed that the reader is at least familiar with the IEEE-488 Interface Bus Standard and terminology. For those that are not, a brief review is presented here but does not go into great detail. A more detailed description of the bus is given in several of the references listed at the end of the article.

What Is The Bus?

IEEE-488 is a concept carefully defined for instrument communication. HP-IB is the implementation of the IEEE-488 Standard. If other words, HP-IB, or GPIB, or IEEE-488 allows you to connect instruments together to form a "system" and



Figure 1. HP 59401A Bus System Analyzer is the technician's tool for bench testing the bus capabilities of a single instrument. The analyzer acts as a listener, talker, or controller for complete testing of an instrument.

exercise that system through a set of predefined commands. Each instrument manufacturer builds in remote programming capabilities and then interfaces the instrument into the system through a standard connector. Figure 2 shows the bus structure, connector, and IEEE-488 Interface.

General Bus Description

Physically, the bus itself is merely a set of sixteen wires (along with a few assorted ground wires and an electrical shield) to which all devices on that bus are connected (see Figure 2). Eight of these wires serve to carry the data messages back and forth over the bus. To maintain order, only one device at a time can place information on these data lines, and that device is known as the active talker. Any or all of the other devices on the bus may sense

the information on these data lines and act on that information. Such a device is known as an active listener. By the nature of the actions which they perform, some devices may be only talkers (e.g., a paper tape reader) or only listeners (e.g., a printer). Other devices such as a digital voltmeter can be either a talker or a listener. It is made a listener so that it can be programmed for the correct voltage range and told when

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to take a reading. It is then made a talker so that it can put the results of that reading on the data bus.

Thus there is a need for one device on the bus to set up talkers and listeners at the proper time, issue instructions to the other devices on the bus, and in general to make sure that all traffic on the bus proceeds in an orderly fashion. This device is called the active controller. Although any device can be designed with controller capability, a calculator or computer with its flexible capability is usually assigned this task.

Finally, there is one and only one special device on the bus known as the system controller. This capability is established by the hardware of the device itself (usually by the setting of a slide switch or a jumper) so that when power is turned on or the bus is reset, the device set to be the system controller will also assume the role of the active controller. At any time, the current active controller may pass control to any other device on the bus that is capable of performing the functions of a controller. (All devices are not required to have this capability.) The role of system controller, however, stays with the device which is physically set for that function and cannot be passed off. At any time when the system controller determines that something has gone wrong with the normal bus operations, it can reset the bus and regain active control.

Refer to Table 1 for a summary of interface bus devices.

Negative-True Logic Description

The interface bus uses the negative-true logic convention to facilitate the wired OR (logical AND) use of the NRFD and NDAC lines. Negative-true logic reduces noise susceptibility in the true state and provides a low power passive false condition (high) on the lines when not in use.

Therefore:

true = low (0 V — 0.8 V)
false = high (2 V — 5.2 V)

Example:

NDAC true (low) =
"none have accepted data"
NDAC false (high) =
"all have accepted data"
NRFD true (low) =
"none are ready for data"
NRFD false (high) =
"all are ready for data"

Bus Structure Details

As shown in Figure 2, sixteen signal lines comprise the complete bus structure. Three are for data byte transfer (handshake), five are for general interface management, and eight are assigned to carry data. The following definitions are used throughout the remaining text.

Source — A device transmitting information on the bus in either the Command or Data mode.

Talker — An "addressed" source in the Data mode only.

Acceptor — A device receiving information on the bus in either the Command or Data mode.

Listener — An "addressed" acceptor in the Data mode only.

Handshake Lines

The handshake lines are used to control the timing of data byte exchanges on the eight DIO signal lines so that the source does not get ahead of the acceptors. DAV is controlled by the source, whereas NDAC and NRFD are controlled by the acceptors. The three handshake lines are:

NRFD — Not Ready For Data. When set false (high) by an acceptor, it indicates to the source that the device is ready to receive data.

DAV — Data Valid. When set true (low) by the source, it indicates that the data on the DIO lines is stable and available to be accepted by the receiver.

NDAC — Not Data Accepted. When set false (high) by the acceptor, it indicates to the source that data has been received. It does not mean the data was acted upon by the acceptor. What it does with the data is determined by the acceptor's internal logic.

TABLE 1. SUMMARY OF INTERFACE BUS DEVICES

Device	Description
Listener	A device capable of receiving data from other instruments. Example of this type of device are: display devices, programmable power supplies, and programmable signal sources.
Talker	A device capable of transmitting data (but not commands) to other instruments. Examples of this type of device are: tape readers, voltmeters that are outputting data, and counters that are outputting data.
Controller	A device capable of managing communications over the bus such as addressing and sending commands. A calculator or computer with an appropriate I/O interface is an example of this type of device.
System Controller	This is an instrument on the bus which has all the features of a standard controller with the added ability to control the IFC and REN lines. The system controller will take control of the bus when power is turned on or the bus is reset or when it determines that something has gone wrong with normal bus operations. The system controller can pass control to other controllers but always retains the system controller status.

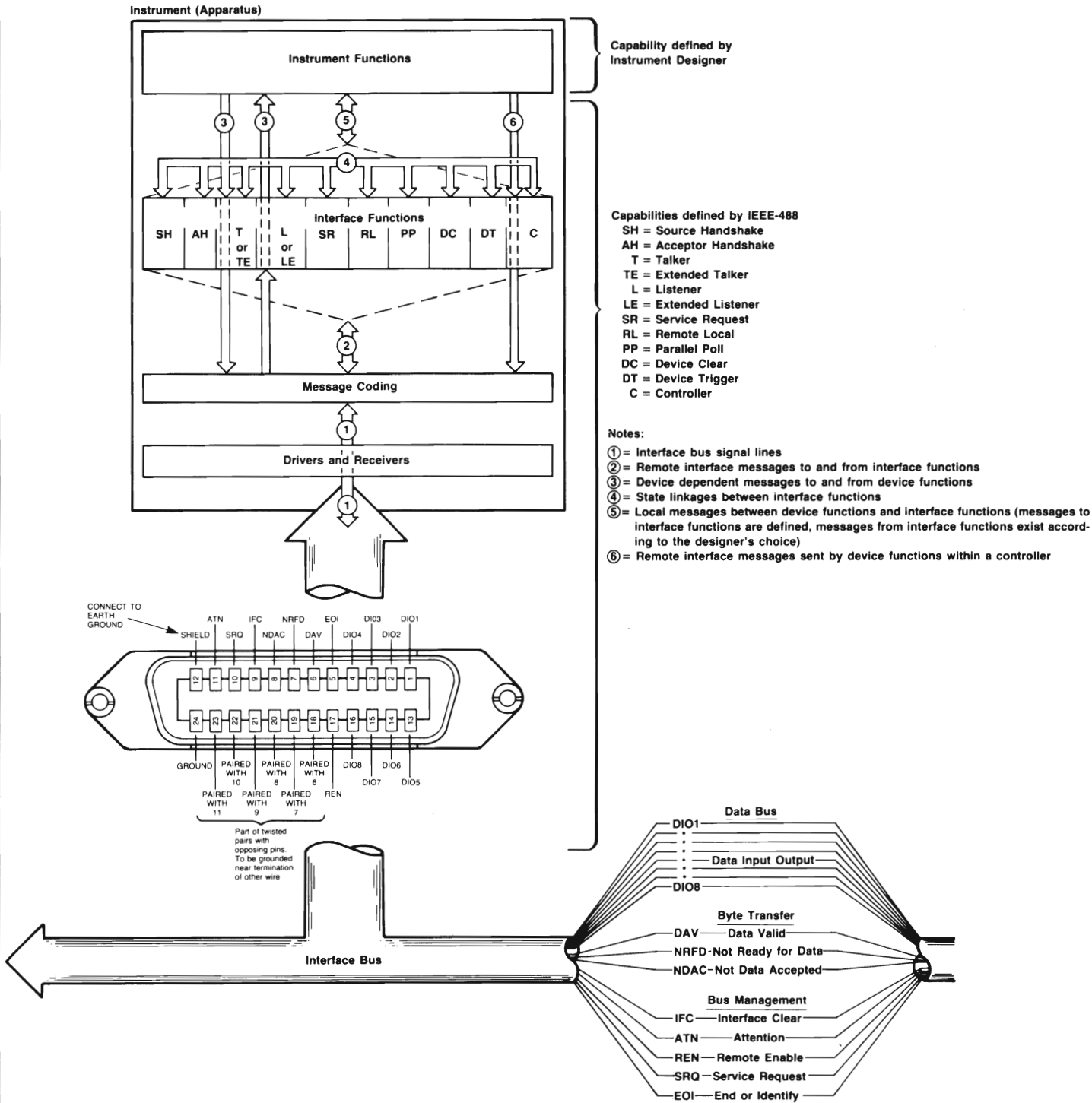


Figure 2. Interface Bus Structure. Note that the instrument can be conceptualized as being partitioned into two areas: instrument functions and interface functions. But the division does not necessarily imply two separate physical layouts within the instrument.

Typical Data Exchange

Using these lines, a typical data exchange would proceed as follows. All devices currently designated as active listeners would indicate (via the NRFD line) when they are ready for data. A device not ready would pull this line low (ground), while a device that is ready would let the line float high. Since a low overrides a passive high, this line will stay low until all active listeners are ready for data. When the talker senses this, it places the next data byte on the data lines and then pulls DAV low. This tells the listeners that the information on the data lines is valid and that they may read it. Each listener (at its own speed) then takes the data and lets the NDAC line go high. Again, only when all listeners have let NDAC go high will the talker sense the situation of data accepted. It can then remove DAV (let it go high) and start the entire sequence over again for the next byte of data. A more detailed description of the handshake process is given in several of the references listed at the end of this article.

General Interface Management Lines

Five interface signal lines are used to manage an orderly flow of information across the interface.

IFC — Interface Clear. Only the system controller can activate this line. When IFC is set true (low), all I/O operations cease and all talkers, listeners, and controllers go to the inactive state. No handshake is required when this line is activated.

ATN — All devices must monitor ATN at all times. When true (low), ATN places the interface in the Command mode where all devices accept (handshake) data on the DIO lines and interpret it as commands. When false (high), ATN places the interface in the Data mode where device-dependent data (e.g., programming or measurement data) is carried between devices previously addressed to talk and listen.

SRQ — Service Request. This line is set true (low) by any instrument requesting service. The controller identifies the device by a serial poll. No handshake is required when this line is activated.

REN — Remote Enable. Only the system controller can activate this line. When set true (low), the bus instruments become "enabled" (made ready) to respond to a listen address from a controller which will place them into the Remote mode. If REN ever goes false (high), all instruments return to local operation.

EOI — End or Identify. This line is used to indicate the end of a transfer sequence or, in conjunction with ATN, to execute a parallel polling sequence. No handshake is required when this line is activated.

Data Input/Output (DIO) Lines

Eight lines carry information bidirectionally between controllers, talkers, and listeners. Normally the information is in the form of a 7-bit ASCII code with the eighth bit available for parity (if desired). Some devices, classed as "extended listeners/talkers," require the full 8 bits in two bytes for addressing. Information transferred includes interface commands, device addresses, and device dependent data. The ATN command line is set true (low) or false (high) by the controller to tell all the devices connected to the bus whether the DIO lines will carry a command or data.

One-On-One Troubleshooting with the HP 59401A

The HP 59401A Bus System Analyzer can be used to bench test and troubleshoot any manufacturer's instrument that is IEEE-488 bus compatible.

Test Objectives

The following tests will show you how to use the HP 59401A Bus System Analyzer to bench test all the bus compatible functions of an instrument. We based some of the

examples on a programmable digital voltmeter and used the analyzer to:

- Verify that the instrument completes the handshake cycle
- Address the instrument to its Remote mode
- Program the instrument for mode, function, range, trigger, etc.
- Cause the instrument to trigger or execute
- Make the instrument a talker and output its data onto the bus
- Read the data and verify that it is correct

Obviously, if the instrument is less complex such as a power supply or switch, you can skip some of the steps and use a less complex test procedure. But whatever type instrument you are testing, by completing these tests you should be able to isolate bus problems to the handshake, DIO, or control lines, and their associated logic within the instrument.

You will also want to make sure your instrument responds to some of the commands listed in Table 2. Check the instrument's Operating Manual to see which ones apply.

Analyzer Operating Tips

Preset the HP 59401A switches as follows:

- LINE to on
- REN to true (up)
- MEMORY to OFF
- COMP to OFF
- TALK/LISTEN to TALK
- EXECUTE switch to HALT
- SRQ, EOI to 0 (down)
- ATN to 1 (up)

The analyzer's display converts the DIO switch settings to their octal value and that octal value to the equivalent ASCII character.



For example:

- Set the switches to 00 / 110 / 010
- The display will show 2 / 062
- Reverse bits 6 and 7 for 01 / 010 / 010
- The display will show R / 122

Whatever value you set in the switch register, the display will convert it to the ASCII/octal equivalent. More settings are shown in Table 3 and on the "Operating Instructions" pull-out card in the front of the analyzer.

When the lights (ATN, etc.) are lit, it means the line is true (low). When the lights are out, it means the line is false (high).

Therefore:

- NDAC lit = "none have accepted data"
- NDAC not lit = "all have accepted data"
- NRFD lit = "none are ready for data"
- NRFD not lit = "all are ready for data"
- DAV lit = "data is valid"
- DAV not lit = "data is not valid"
- ATN lit = "data byte is a command"
- ATN not lit = "data byte is data"
- EOI lit = "end of data"
- SRQ lit = "instrument requests service"

Device Addresses

Device addresses are used by the active controller to specify who talks and who listens on the bus. A device's address is usually preset at the factory by an address switch or jumpers. The switch usually contains 5 bits and is typically located on the outside rear panel of the instrument, but could be internal. In

addition to the address switch, there is usually a switch that is labeled TALK ONLY/ADDRESSABLE. This switch must be set to ADDRESSABLE so the analyzer can enable the instrument to its Remote mode.

The instrument's "basic address" is 5 bits long and is set by DIO bits 1-5. Since the 59401A works in octal, the address must be loaded in octal. If your instrument address is listed as a decimal number, convert it to octal with Table 3.

Example:

- An instrument's address is listed as decimal 17.
- Table 3 shows decimal 17 to be octal 021.
- Set the DIO switches to 00 / 010 / 001
- The display will show 021.

Bits 6 and 7 are added to the "basic address" to distinguish between a talk and listen address. For listen, bit 6 is "1" and b7 is "0". For talk, b6 is "0" and b7 is "1". The basic address remains the same.

However, when you add bits 6 and 7 to bits 1 through 5, the whole octal number changes as shown in the following example.

Example:

- As above, the basic address is octal 021.
- Now add in DIO switches 6 and 7 to form 00 / 110 / 001

— Note the "new" octal number is 061 (ASCII 1).

— This is the instrument's listen address.

— Reverse bits 6 and 7. The DIO switches should read 01 / 010 / 001.

— Note the "new" octal number is 121 (ASCII Q).

— This is the instrument's talk address.

After completing the above example, note that the instrument's "basic address" bits were not touched; however, the talk and listen bits 6 and 7 did alter the octal number. This will be true of all instrument addresses. Bits 1-5 remain the same and you change bits 6 and 7 to make it a talk or listen address. Refer to Figure 3.

Set-Up Procedure

If your instrument requires an external stimulus, hook it up now. For example, if it's a DVM, connect a voltage (battery) to the terminals, or if it's a power supply connect a load to it. Connect the HP 59401A to the instrument with the bus cable. Set the analyzer's switches as before under the heading Operating Tips.

Testing the Handshake and Listen Address

The following steps will:

- check the DIO lines for open or shorted conditions
- Check the handshake process
- address the instrument to its Remote mode.

	DIO								
	8	7	6	5	4	3	2	1	
listen	=	0	0	1	1	0	0	0	= 061 (ASCII 1)
talk	=	0	1	0	1	0	0	0	= 121 (ASCII Q)

Figure 3. Talk/Listen Address Example.

1. Look up the instrument's address and write it down. If you can't find the address, go to step 5.

2. Set the DIO switches to the instrument's "basic address." Note that if the address is provided as a decimal number, you can convert it to octal with Table 3.

3. Set bit 6 up and bit 7 down. This converts the instrument's "basic address" to its listen address.

4. Press and hold EXECUTE. DAV and NRFD will light and NDAC will go out. Release EXECUTE. This indicates that the handshake was completed (refer to Tip #1). It does not mean that the address was acted upon by the instrument. What it does with the data is determined by the instrument's internal logic.

— If the address was accepted, the REMOTE light on the instrument will light. If there is no indicator for the Remote mode, then switch ATN down (false) and watch the NDAC light. If it goes out, the address was not accepted (refer to Tip #2). If it stays lit, the instrument has accepted the listen address in Remote and is now ready for the next data byte. The reason it stays lit is that the instrument's internal logic has responded to the address and allowed the interface to proceed to the next step in the handshake cycle. Remember that a device that is unaddressed must handshake every address but get off the bus during a data transfer. (Note that when you switch ATN down (light off) you are telling the bus the next data byte will be data and not a command.)

TROUBLESHOOTING TIP #1

Each time you press EXECUTE, the handshake lights should perform as follows:

EXECUTE in —
DAV on, NRFD on, NDAC off.

EXECUTE out —
DAV off, NRFD off, NDAC on.

Remember that DAV is controlled by the HP 59401A, and NRFD/NDAC are held low by the instrument.

Hint — NRFD and NDAC cannot both be false (indicators off) at the same time.

Searching for the Listen Address and Testing the DIO Lines

5. Complete the following steps if you cannot find the instrument's address, or if you believe the DIO lines are bad. If you have successfully set the instrument to its Remote mode, go to step 9.

6. Set the DIO switches as follows:

— b8 = 0
— b7 = 0
— b6 = 1
— b5
•
• = 0
— b1

7. The octal readout on the HP 59401A will be 040 and the ASCII character will be a blank or SP (space). Press and hold EXECUTE. DAV and NRFD will light and NDAC will go out. Release EXECUTE. This indicates that the handshake was completed (refer to Tip #1). It does not mean that the address was acted upon by the instrument. What it does with the data is determined by the instrument's internal logic.

— If the address was accepted, the REMOTE light on the instrument will light. If there is no indicator for the Remote mode, then switch ATN down (false) and watch the NDAC light. If it goes out, the address was not accepted. If it stays lit, you have found the address and the instrument is in its Remote mode. The reason it stays lit is that the instrument's internal logic has responded to the address and allowed the interface to proceed to the next step in the handshake cycle. Remember that a device that is unaddressed must handshake every address but get off the bus during a data transfer. (Note that when you switch ATN down (light off) you are telling the bus that the next data byte will be data and not a command.)

8. Repeat this process for the next address of 041 (ASCII !), then 042, 043, etc. Continue this process until you have tested all 31 combinations of bits 1-5. During this procedure you should discover the correct listen address for the instrument. **WRITE IT DOWN!**

TROUBLESHOOTING TIP #2

If the instrument does not go into its Remote mode, the DIO lines may be open or shorted, or the instrument's internal logic may be bad. To check for "shorts," perform steps 5 through 8 and make certain the octal readout changes each time you change an address switch. To check for "opens," go to the address lines inside the instrument and monitor them with a logic probe as you are switching. Also check the internal addressing logic to make sure it's functioning properly.

9. At this point the instrument should be in its Remote mode sitting there waiting for you to tell it what to do next. If not, refer to Tip #2. Otherwise continue reading.

Programming the Instrument

Programming your instrument involves using the HP 59401A as a controller to send some precise program codes that will set the instrument's range, function, mode, etc. These codes must be obtained from the instrument's Operating Manual. Some examples might be:

FUNCTION

DC Volts = F1
AC Volts = F2
OHMS = F3

RANGE

.1 = R1
1 = R2
10 = R3
100 = R4

Note that these codes are considered data words and must be sent with ATN false.

Some instruments also recognize general IEEE-488 commands that will cause the instrument to get off the bus (become "unaddressed") or set itself to a pre-determined state or initiate an action. These commands are listed in Tables 2 and 4. Note that since these are commands ATN must be true.

All of the following steps are totally dependent on how the functions of your instrument are programmed (i.e., function, mode, range, trigger, etc.). Refer to your Operating Manual and look for a description or table of GPIB (or HP-IB) program codes. Read it carefully and write down the ASCII characters of the functions you want to program. You can use Table 3 to convert these ASCII codes to octal numbers.

NOTE

When you set the DIO switches on the analyzer, pay close attention as to whether you are sending a command or data word. Remember;
ATN = 1 (true) = command word
ATN = 0 (false) = data word

10. Set the HP 59401A switches as follows:

- REN to true (up)
- MEMORY to OFF
- COMP to OFF
- TALK/LISTEN to TALK
- EXECUTE switch to HALT
- SRQ, EOI to 0 (down)
- ATN to 1 (up)

11. Set the DIO switches to the instrument's listen address and press EXECUTE. This reaffirms that the instrument is in its Remote mode. (Note that this is a command word because ATN is set to 1 (true)).

12. Change ATN to 0 (false). This means that the next word sent to the instrument will be a data word.

13. Set the DIO switches to the first program code word.

Example:

- Function = ASCII F = octal 106
- The DIO switches would be 01 / 000 / 110

14. Press EXECUTE.

15. Set the DIO switches to the next program code word.

Example:

- DC Volts = ASCII 1 = octal 061
- The DIO switches would be 00 / 110 / 001

16. Continue sending the codes until your instrument is fully programmed.

17. If you decide to try the Group Execute Trigger (GET) command to trigger your instrument, don't forget to set ATN true.

18. Once the instrument is programmed and triggered, you want to address it as a talker to make the

data available on the bus so you can read it with the analyzer.

Set the instrument's talk address into the DIO switches. Remember that the talk address has b7 up and b6 down. Set ATN up (true).

19. Press EXECUTE. The instrument should now be a talker and output its data onto the bus. Set the TALK/LISTEN switch to LISTEN. This makes the analyzer a listener and since the instrument is a talker, the DAV indicator should light. The SRQ indicator may or may not be lit — it depends on each individual instrument. The first data byte from the instrument should be displayed. Write the reading down on a piece of paper. Each time you press EXECUTE, the next data byte is read into the display. Be sure and write each one down.

— If the analyzer's display is all zeros, check that the instrument was triggered, and check that the instrument is a talker.

Hint — Each time the instrument is triggered, it should give you indication (e.g., front panel indicators change or a gate light flashes).

— If the data is meaningless, recheck the program codes and retrigger the instrument.

Hint — Some instruments use a storage buffer between the displayed data and the bus.

20. Refer to the instrument's Operating Manual to determine the format of the transmitted data. When you get to the end of the data reading, the analyzer's EOI light may light (true) indicating the end of the data byte. In Hewlett-Packard instruments, the last data byte is usually LF (line feed) which is octal 012 (i.e., when you see 012 EOI should light). You must check the instrument's Operating Manual to see if EOI is pulled true at the end of the data string.

Summary

This completes the test. In summary, you have performed the following steps:

- Verify that the instrument completes the handshake cycle.
- Addressed the instrument and caused it to respond.
- Told the instrument to complete its assigned task; i.e., take a measurement, output a voltage, etc.
- Made the instrument a talker and output its data onto the bus.
- Read the data and verified that it was correct.

Admittedly this is a simplified procedure for a complex standard. It cannot exercise an instrument in the sophisticated manner of a calculator or computer controller. But then you would have to write programs for the calculator/computer and it would not allow you to wiggle each line of the bus separately and watch the results. It is this close monitoring of bus activity with the HP 59401A that allows you to isolate problems faster.

If you have any comments on this article or suggestions for an upcoming system troubleshooting article, please contact the editor at the address listed on the back page of *Bench Briefs*.

References:

IEEE Std 488-1978; Condensed Description of the Hewlett-Packard Interface Bus (HP p/n 59401-90030); Tutorial Description of the Hewlett-Packard Interface Bus (HP p/n 59300-90007); Interfacing Concepts and the 9825A (HP p/n 09825-90060); HP-IB Troubleshooting, an HP service training course created by Les Young, HP Mt. View.

TABLE 2. SUMMARY OF BUS COMMANDS THAT MOST INSTRUMENTS WILL RECOGNIZE

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

NOTE: Talkers can also be unaddressed by transmitting an unused talk address on the Bus. This is not true with listeners.



**TABLE 3. ASCII TO BINARY TO OCTAL TO DECIMAL
CONVERSION TABLE**

ASCII Character Codes

ASCII Char.	EQUIVALENT FORMS			ASCII Char.	EQUIVALENT FORMS			ASCII Char.	EQUIVALENT FORMS			ASCII Char.	EQUIVALENT FORMS		
	Binary	Octal	Dec		Binary	Octal	Dec		Binary	Octal	Dec		Binary	Octal	Dec
NULL	00000000	000	0	space	00100000	040	32	@	01000000	100	64	.	01100000	140	96
SOH	00000001	001	1	!	00100001	041	33	A	01000001	101	65	a	01100001	141	97
STX	00000010	002	2	"	00100010	042	34	B	01000010	102	66	b	01100010	142	98
ETX	00000011	003	3	#	00100011	043	35	C	01000011	103	67	c	01100011	143	99
EOT	00000100	004	4	\$	00100100	044	36	D	01000100	104	68	d	01100100	144	100
ENQ	00000101	005	5	%	00100101	045	37	E	01000101	105	69	e	01100101	145	101
ACK	00000110	006	6	&	00100110	046	38	F	01000110	106	70	f	01100110	146	102
BELL	00000111	007	7	'	00100111	047	39	G	01000111	107	71	g	01100111	147	103
BS	00001000	010	8	(	00101000	050	40	H	01001000	110	72	h	01101000	150	104
HT	00001001	011	9	)	00101001	051	41	I	01001001	111	73	i	01101001	151	105
LF	00001010	012	10	*	00101010	052	42	J	01001010	112	74	j	01101010	152	106
V _{tab}	00001011	013	11	+	00101011	053	43	K	01001011	113	75	k	01101011	153	107
FF	00001100	014	12	,	00101100	054	44	L	01001100	114	76	l	01101100	154	108
CR	00001101	015	13	-	00101101	055	45	M	01001101	115	77	m	01101101	155	109
SO	00001110	016	14	.	00101110	056	46	N	01001110	116	78	n	01101110	156	110
SI	00001111	017	15	/	00101111	057	47	O	01001111	117	79	o	01101111	157	111
DLE	00010000	020	16	Ø	00110000	060	48	P	01010000	120	80	p	01110000	160	112
DC ₁	00010001	021	17	1	00110001	061	49	Q	01010001	121	81	q	01110001	161	113
DC ₂	00010010	022	18	2	00110010	062	50	R	01010010	122	82	r	01110010	162	114
DC ₃	00010011	023	19	3	00110011	063	51	S	01010011	123	83	s	01110011	163	115
DC ₄	00010100	024	20	4	00110100	064	52	T	01010100	124	84	t	01110100	164	116
NAK	00010101	025	21	5	00110101	065	53	U	01010101	125	85	u	01110101	165	117
SYNC	00010110	026	22	6	00110110	066	54	V	01010110	126	86	v	01110110	166	118
ETB	00010111	027	23	7	00110111	067	55	W	01010111	127	87	w	01110111	167	119
CAN	00011000	030	24	8	00111000	070	56	X	01011000	130	88	x	01111000	170	120
EM	00011001	031	25	9	00111001	071	57	Y	01011001	131	89	y	01111001	171	121
SUB	00011010	032	26	:	00111010	072	58	Z	01011010	132	90	z	01111010	172	122
ESC	00011011	033	27	;	00111011	073	59	[	01011011	133	91	{	01111011	173	123
FS	00011100	034	28	<	00111100	074	60	\	01011100	134	92	}	01111100	174	124
GS	00011101	035	29	=	00111101	075	61	]	01011101	135	93	~	01111101	175	125
RS	00011110	036	30	>	00111110	076	62	^	01011110	136	94	~	01111110	176	126
US	00011111	037	31	?	00111111	077	63	_	01011111	137	95	DEL	01111111	177	127

TABLE 4. ALL TALK AND LISTEN ADDRESS COMBINATIONS WITH ADDRESSED AND UNIVERSAL COMMANDS

ASCII/ISO & IEEE CODE CHART

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

KEY

octal	25	PPU
	NAK	
hex	15	21

Message Mnemonic (refer to Table 2)
 ASCII/ISO character
 decimal

BENCH BRIEFS INDEX

Need Any Service Notes?

Here's the latest listing of Service Notes available for Hewlett-Packard products. To obtain information for instruments you own, remove the order form and mail it to the HP distribution center nearest you.

GENERAL

5083-6. Do not remove black tape on CRT bases.

312B/D SELECTIVE VOLT/LEVEL METER

312B/D-6. All serials. Recommended replacement part numbers for LED displays.

339A DISTORTION ANALYZER

339A-5. Serials 1730A-01955 and below. Solution to range-to-range distortion problem.
339A-6. Serials 1730A-02155 and below. Switch-shaft coupler change to improve reliability.
339A-7. Serials 2025A-02365 and below. Solution to inadequate frequency vernier overlap.

410C ELECTRONIC VOLTMETER

410C-18. Recommendations for padding resistor A3R30.

432B POWER METER

432B-3. Serials 1913A and below. Recommended digital panel meter installation kit.

432C POWER METER

432C-3. Serials 1906A and below. New and improved digital panel meter installation kit.
432C-4. Serials 1906A and below. Auto range assembly replacement for remote operation.

467A POWER SUPPLY/AMPLIFIER

467A-4. Serial 0994A04125 and below. Recommended replacement parts for Q1 - Q4.

546A LOGIC PULSER

546A-1. Serial 1732A and below. Recommended filter capacitor (0.1 μ f ceramic) for improved power line filtering.

1114A TESTMOBILE

1114A-1A. All serials. Swivel caster replacement.

1220A OSCILLOSCOPE

1220A-3. Replacement of obsolete boards.

1221A OSCILLOSCOPE

1221A-3. Replacement of obsolete boards.

1222A OSCILLOSCOPE

1222A-3. Replacement of obsolete boards.

1302A DISPLAY

1302A-2A. Serials 1643A and below. Improved CRT arc suppression.

1304A DISPLAY

1304A-2A. Serials 1715A and below. Improved CRT arc suppression.

1311B DISPLAY

1311B-1. Serials 1943A. Improved reliability of 250V low voltage power supply.
1311B-1A-S. All 1311B displays. Notification X-ray emission hazard.

1332A X-Y DISPLAY

1332A-12. Serials 1949A11824 to 1949A13709. Improved reliability for the +100V power supply.

1333A X-Y DISPLAY

1333A-7. Serials 1950A03516 to 1950A03744. Improved reliability for the +158V power supply.

1335A X-Y DISPLAY

1335A-11. All prefixes. Specifications for storage CRT's.
1335A-12. Serials 1949A08866 to 1949A09490. Improved reliability for the +158V power supply.

1611A LOGIC ANALYZER

1611A-8B. Serials 1837A-02232 and below. Eliminating bright spot on CRT after turn off.

1615A LOGIC ANALYZER

1615A-3. Serials 1937A-03487 and below. Eliminating bright spot on CRT after turn off.

1640A LOGIC ANALYZER

1640A-4B. Serials 1845A-01199 and below. Eliminating bright spot on CRT after turn off.
1640A-8A. Serials 1845A01123 and below. Preferred crystal replacement for increased clock accuracy.

1640A SERIAL DATA ANALYZERS

1640A-9. All serial numbers. 1640A-to-model B conversion kits.

1725A OSCILLOSCOPE

1725A-5. All serials. Modification kit for probe power jacks.

1980A/B OSCILLOSCOPE

1980A/B-1. Service kit of elastomeric connectors now available. Order 01980-69501.

3042A NETWORK ANALYZER

3042A-2. All serials. Troubleshooting tips for sweep problems.

3045A SPECTRUM ANALYZER

3045A-1A. All serials. Troubleshooting tips for sweep problems.

3060A CIRCUIT TEST SYSTEM

3060A-14. All serials. Confirmation/configuration/diagnostics modifications for revision 2027.
34196A-1. All serials. Modification for optional C31 62215E power supply wiring.

3312A FUNCTION GENERATOR

3312A-4. Serials 1432A06631 and below. Suggested modifications to prevent output signal clipping/frequency variations

3330B AUTOMATIC SYNTHESIZER

3330A/B-14A. Serials 1313A01918 and below. Correct termination of HP-IB lines on A34 assembly (read this when changing A6 assemblies on the above units).
3330B-15A. All serials. Troubleshooting tips for sweep problems in system applications.

3438A DIGITAL MULTIMETER

3438A-1. All serials. Notification of replaceable fuse link in amps circuit.
3438A-4A. All serials. Correction of ICU726 signatures for signature analyzer troubleshooting.

3455A DIGITAL VOLTMETER

3455A-18A. Serials 1622A09090 and below. Preferred replacement of FET's A10Q1, Q2, Q3, Q4, Q13, Q14, Q15, Q16, Q18, Q19, Q21, Q38 and Q39.
3455A-19. All serials. Preferred replacements of front panel digit displays.

3496A SCANNER

3496A-1. Serials 1740A00343 and below. Caution to prevent serious scanner mechanical damage.
3496A-2. Serials 1740A00192 through 1740A00499 (bezel fasteners only), and serials prior to 1740A00191 (both changes applicable). Improved bezel and rear grill fasteners.

3570A NETWORK ANALYZER

3570A-12. All serials. Troubleshooting tips for sweep problems in system applications.

3571A SPECTRUM ANALYZER

3571A-1. All serials. Troubleshooting tips for sweep problems in system applications.

3582A SPECTRUM ANALYZER

3582A-7. All serials. Modifications to improve reliability.

3585A SPECTRUM ANALYZER

3585A-2A. Serials 1750A00466 to 540 and 1750A00631 to 661. A1 board relay changes from 12 volt to 5 volt.

3722A NOISE GENERATOR

3722A-6A. Serials 1451U-01205 and below. Modification to prevent excessive count on infinite sequence length.

3745A/B SELECTIVE LEVEL MEASURING SET

3745A/B-15A. All serials. Retrofitting instructions for option 021-CCITT weighted noise and phase jitter measurements.
3745A/B-20D. Serials 1812U and below. Retrofit kits for special options H15 and H16.
3745A/B-30A. Serials 2010U and below. Preferred replacement of memory assembly A109.

3770A AMPLITUDE/DELAY DISTORTION ANALYZER

3770A-41. All serials. Preferred replacement of 4-bit bistable latch, HP part number 1820-0876.

3770B TELEPHONE LINE ANALYZER

3770B-22. All serials. Preferred replacement of 4-bit bistable latch, HP part number 1820-0876.

3771A/B DATA LINE ANALYZER

3771A/B-6A. Serials below 1937U-00160 (3771A) and 1937U-00123 (3771B). Preferred replacement of E1 mains module.
3771A/B-15A. 3771A serials 2002U-00180 and below; 3771B serials 1937U-00123 and below. Modification to prevent possible loss of the 2040Hz transmission frequency when frequency shift is selected in the 3771A.
3771A/B-18. All serials. Retrofitting instructions for HP-IB option 005.

4942A TIMS

4942A-4A. All serials. A6 or A17 RF cable replacement compatibility.
4942A-5. All serials. A4, A5, A6 or A17 board RF cable compatibility.
4942A-6. All serials. A4-A5 RF cable replacement compatibility. Supersedes 4944A-5.

4943A TIMS

- 4943A-6A. Serials 1731A00290 and below. A3, A5, A6 or A17 board RF cable compatibility.
 4943A-8A. Serials 1731A00290 and below. A6 or A17 RF cable replacement compatibility.
 4943A-9. Serials 1731A00254 and below. Option 010. Recommendation parts replacement to improve performance during HP-IB operation.

4944A TIMS

- 4944A-5B. Serials 1737A00570 and below. A4-A5 RF cable replacement compatibility.
 4944A-7A. Serials 1737A00570 and below. A7 or A17 RF cable replacement compatibility.
 4944A-8. Serials 1737A00570 and below. A3, A4, A5, A6 or A17 board RF cable compatibility.

5004A SIGNATURE ANALYZER

- 5004A-4. All serials. New data probe setup and hold time test procedures for User and Service manuals.

5045A DIGITAL IC TESTER

- 5045A-21. All serials. Operating and Service manual supplement containing a new instrument block diagram and description.

5061A CESIUM BEAM FREQUENCY STANDARD

- 5061A-10. Alternate replacement for A10 oscillator assembly.

5314A UNIVERSAL COUNTER

- 5314A-1. All serials. Recommended replacement part numbers for yellow LED displays.

5315A/B 100 MHz UNIVERSAL COUNTER

- 5315A/B-3. All serials. Modification to improve electrical connection on A5 triangular support assemblies.

5328A UNIVERSAL COUNTER

- 5328A-27. Serial 1944A13473 and below. How to retrofit the new A15 HP-IB assembly (05328-60043).

5335A UNIVERSAL COUNTER

- 5335A-1. All serials. 5335A HP-IB verification program using the 9825A controller.

5340A MICROWAVE FREQUENCY COUNTER

- 5340A-14. Serials 2008A06751 and below. Conversion to LED digital display.
 5340A-15. Prefix 2088 and above. Test procedure to verify -15 dBm sensitivity, 18 GHz to 23 GHz, at room temperature.

5342A MICROWAVE FREQUENCY COUNTER

- 5342A-10A. All prefixes prior to 2020 and all prefixes 2020 and after with option 002. Recommended procedure for replacing low frequency input fuse.
 5342A-11B. All serials. Revised procedure for replacing ground fingers on assemblies A4, A5, and A8.
 5342-20. After prefix number 2020. New low frequency input connector fuse.
 5342A-21. All serials prefixes before 1828. Recommended method to reduce I.F. noise on instruments with Option 004 (DAC Option).
 5342A-22A. Serials 2014 and above. Option 005 test and troubleshooting procedure.
 5342A-23. Prefixes before 2024. Recommended guard plate to protect ribbon cables.
 5342A-25. Serials 2020 and below. Modification to correct miscounting above 6 GHz.

5343A MICROWAVE FREQUENCY COUNTER

- 5343A-1. Serials 2024 and below. Modification to install guard plate to protect cables.
 5343-4. Serial prefixes 2020 and below. Modification to correct miscounting above 6 GHz.
 5343A-5. Serial prefixes 1936A and below. Modification to correct miscount above 26 GHz.
 5343A-6. All serials. Modification to add jumper to U15 on A16 assy. to improve RAM READ/WRITE performance.
 5343A-7. All serials. Procedure to correct miscounts between 24-26.5 GHz.

5345A ELECTRONIC COUNTER

- 5345A-9A. 9825 HP-IB verification program for 5345A, Opt. 011.
 5345A-12A. 9825 HP-IB verification program for 5345A, Opt. 012.
 5345A-16A. A13 boards with series 1820 and 1912. Modification to prevent miscounting caused by noise on reg. clk. line.

5363B TIME INTERVAL PROBES

- 5363B-6. Serials 2028A00460 and below. Fuse type and rating change.

5370A UNIVERSAL TIME INTERVAL COUNTER

- 5370A-1A. All serials. 9825 HP-IB verification program for 5370A.
 5370A-4A. All serials. Operating and Service manual supplement containing new adjustment procedure for input assemblies (A3, A4).
 5370A-9. Serials 2008A00670 and below. Recommended replacement for 18 pin DIP sockets.

5420A DIGITAL SIGNAL ANALYZER

- 5420A-25. New exchange assembly configuration for the 2105A computer "A" type power supply.
 5420A-26. 5420A serials 1940A thru 2012A. Modification to the 54410A "CM" (common mode switch).

5423A STRUCTURAL DYNAMICS ANALYZER

- 5420A-26. 5423A serials 2022A and below. Modification to the 54410A "CM" (common mode switch).

5451B FOURIER ANALYZER SYSTEM

- 5451B-20. 5460C display unit. Serial prefix 2020A and above. Numeric display change from NIXIE* to LED readouts.

5451C FOURIER ANALYZER SYSTEM

- 5451C-01. 5460A display unit. Serial prefix 2020A and above. Numeric display change from NIXIE* to LED readouts.
 5451C-2. 181AR variable persistence oscilloscope. Special bottom cover to eliminate electromagnetic interference.

6140A DIGITAL CURRENT SOURCE OPTION J99 and P05.

- 6140A-2. Serials 2004A-00340 and below. Modification to avoid system hang-ups.

7010B/7015B X-Y RECORDERS

- 7010B-2A/7015B-2A. Serials 1749A to 2008A. Modification to prevent 8 volt regulator failures.

7047A X-Y RECORDER

- 7047A-4. Serials 1837A and below. Recommended parts replacement to prevent possible failure of +15V regulator 1C6 P/N 1826-0106 PCA 07047-60100 X-axis amplifier.

7220A/7221A PLOTTERS

- 9872A/B/S-2, 7221A/B/S-2, 7220A/S-2. All serials. Plotter pen travel, height, force and damping adjustments.

7562A LOG VOLTMETER CONVERTER

- 7562A-3. Serial below 1942A. Recommended replacement for AC amplifier PCA 07562-80020.

7906 DISC DRIVE

- 12940A-1. 12940A disc cartridge with date codes K9-81000 through K9-81500 and L9-80000 through L9-81750. Disc cartridge exchange program.

8012B PULSE GENERATOR

- 8012B-5. Serials 1412G00400 and below; serials 1442A11471 and below except SN11339, SN11422, SN11452, SN11458, SN11460, and SN11469. Modification to correct integrator error at low repetition rate and minimum pulse width.

8165A PROGRAMMABLE SIGNAL GENERATOR

- 8165A-9. All serials. Excessive output voltage may damage relays.

8505A NETWORK ANALYZER

- 8505A-11. Serial 1930A and below with Option 005 phase lock. Recommended replacement for mixer kit, HP part number 08505-60240.

8554B AND 8554L SPECTRUM ANALYZER RF SECTIONS

- 8554B-3A. 8554B serials 2011A and below; 8554L all serials. RF input attenuator replacement kit.

8557A SPECTRUM ANALYZER

- 8557A-2. All serials. Recommended replacement for transistors A4Q9, 13, 14, 16 or A12Q13, 15, 18, 20.

8558B SPECTRUM ANALYZER

- 8558B-20. All serials. Recommended replacement for transistors A7Q9, 11 and A12Q10, 11.

8565A SPECTRUM ANALYZER

- 8565A-5B. All serials. Recommended YTO replacement kit.
 8565A-6A. Serials 1937A and below. Recommended bandwidth filter replacement kit.

8566A SPECTRUM ANALYZER

- 8566A-8. All serials. HP part number for B&W Associates flexible cable assembly.

8568A SPECTRUM ANALYZER

- 8568A-33. All serials. Procedure for adjusting high voltage.
 8568A-35. All serials. Recommended replacement for ROM's A3A5 and A3A6.
 8568A-37. All serials. Procedure for replacement of the calibration ROM when replacing the RF attenuator.

9571A-DTS 70

- 9571A-18. Contents of product support package for the 9571A-revised June 1980.

9872A/B/S PLOTTER

- 9872A/B/S-2, 7221A/B/S-2, 7220A/S-2. All serials. Plotter pen travel, height, force and damping adjustments.

12940A DISC CARTRIDGE

12940A-1. Date codes: K9-81000 through K9-81500 and L9-80000 through L9-81750. Disc cartridge exchange program.

3060A CIRCUIT TEST SYSTEM

34196A-1. All serials. C31 62215E power supply wiring.

37201A HP-IB EXTENDER

37201A-2. Serials 1925U00666 and below. PROM change to solve specific applications problems.

59308A TIMING GENERATOR

59308A-3A. Serials 1740A00466 through 2012A00965. Modification to correct A1C23 bypass capacitor installation.

64000 LOGIC DEVELOPMENT SYSTEM

12940A-1. 12940A disc cartridge with date codes K9-81000 through K9-81500 and L9-80000 through L9-81750. Disc cartridge exchange program.

64202A-1. 64202A 8080 emulator subsystem. Emulator control board repair number 2008A-00300 and below. Emulator pod all repair numbers. Modification to improve performance of user's READY signal override.

64202A-2. 64202A 8080 emulator subsystem. Emulator pod all repair numbers. Modification to provide user's READY signal input synchronization.

64203A-1. 64203A 8085 emulator subsystem. Emulator control board repair number 2008A-00300 and below. Modification to prevent illegal opcode condition.

64203A-2. 64203A 8085 emulator subsystem. Emulator control board repair number 2008A-00300 and below. Emulator pod repair number prefix 2017A and below. Modification to improve performance of user's READY signal override.

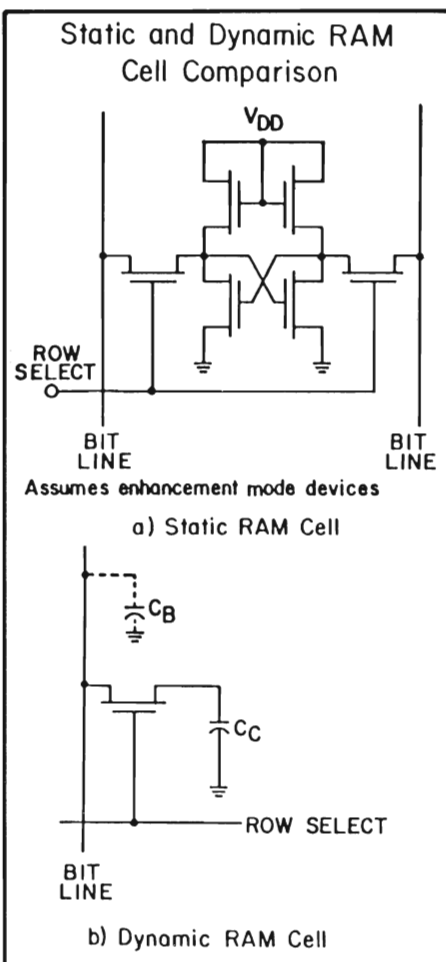
64203A-3. 64203A 8085 emulator subsystem. Emulator pod repair number prefix 2017A and below. Modification to disable improper HLDA signal.

64203A-4. 64203A 8085 emulator subsystem. Emulator pod repair number prefix 2017A and below. Modification to provide user's READY signal input synchronization.

64252A-1. 64250A Z80 emulator subsystem. Pod repair number prefix 2003A-only. Z80 emulator interrupt and jumper options.

64252A-2. 64250A Z80 emulator system. Repair number prefix 2003A-only. Modification to synchronize user WAIT signal.

What is Dynamic RAM Refresh?



RAMs are integrated circuit memories into which data bits can be written and then read out again. All RAMs are classified according to whether they are static or dynamic and according to whether they are manufactured by a bipolar or an MOS process. If the cell circuit is basically a flip-flop, the device is referred to as a static RAM; if the cell

uses a capacitive element for storing the data bit, it is called a dynamic RAM.

The difference between dynamic and static RAMs is easier to understand by considering the individual memory cell circuits. A dynamic memory cell is always an MOS type and consists of one or more transistors and a capacitive element, on which the data bit is stored as a charge. Commonly, there are one, two, three, or four transistor cells, each type having some advantages and disadvantages.

Since the dynamic cell contains a capacitor, and because a capacitor and other junctions in the cell have leakage, the charge has to be periodically restored. This is done during a

refresh cycle once every few milliseconds, when the capacitors in all cells throughout the memory that store a charge (logic 1 bit) are recharged. This recharging can be viewed as regular "write" cycles that keep the logic 1 levels up above the "forbidden zone" (that area between logic 1 and logic 0). Recharging is also accomplished whenever the data is read out of a cell. On the other hand, a refresh cycle has to be reckoned with, even though it may require the interrupting of read and write operations.

Since a static RAM consists of a flip-flop circuit and consequently no capacitive element, there is no need for a refresh cycle, the associated refresh power source, cycle control logic, etc.

Attention 5342A/5343A Automatic Microwave Frequency Counter Users

This issue of *Bench Briefs* contains many new Service Notes that describe procedures for improving performance and protection of your counters. Please take a moment to look over the list and compare serial number applicability. The notes are free, just use the order form at the rear of *Bench Briefs*.



CUSTOMER SERVICE TRAINING CALENDAR FOR 1981

CONTENT	DATES	LOCATION	TUITION	COORDINATOR
Logic Analyzers				
Logic State Analyzer Maintenance Models 1610A/B, 1611A, 1615A, 1640A (2.5 days each)	March 16 - 27	Colorado Springs Division 1900 Garden of the Gods Road Colorado Springs, CO 80907 (303) 598-1900	\$ 300/student	Jerry Lopez
Microcomputer Development System Model 64000	March 2 - 13 August 10 - 21	Colorado Springs Division	\$1,250/student	Jerry Lopez
Scopes and Displays				
Models 1715A/1725A (Order HP No. 5955-4146)	March 23 - 25 October 5 - 7	Colorado Springs Division	\$ 300/student	Dick Browne
Models 1740A/1741A/1742A/1744A (Order HP No. 5955-4147)	March 16 - 19 September 28 - October 1	Colorado Springs Division	\$ 350/student	Dick Browne
Models 1980B/1950A/19860A (Order HP No. 5955-8046)	March 9 - 13 September 21 - 25	Colorado Springs Division	\$ 400/student	Dick Browne
Models 1302A, 1304A P/N 5955-8049	March 2 September 21	Colorado Springs Division	\$ 200/student	Margie Collins
Models 1310A/B, 1311A/B, 1317A/B, 1321A/B P/N 5955-8050	March 3 September 22	Colorado Springs Division	\$ 200/student	Margie Collins
Models 1332A, 1333A, 1335A P/N 5955-8051	February 23 September 14	Colorado Springs Division	\$ 200/student	Margie Collins
Model 1336S P/N 5955-8052	February 24 - 25 September 15 - 16	Colorado Springs Division	\$ 250/student	Margie Collins
Model 1338A P/N 5955-8053	February 25 - 26 September 16 - 17	Colorado Springs Division	\$ 250/student	Margie Collins
Model 1340A P/N 5955-8054	February 27 September 18	Colorado Springs Division	\$ 200/student	Margie Collins
Model 1350A P/N 5955-8055	February 4 - 6 September 23 - 25	Colorado Springs Division	\$ 300/student	Margie Collins
Automatic Test				
Circuit Test Systems Model 3060A	January 19 - 30 February 23 - March 6 March 30 - April 10 May 4 - 15 June 15 - 26 July 20 - 31 August 24 - September 4 September 28 - October 9 November 2 - 13 December 7 - 18	Loveland Instrument Division 815 Fourteenth Street, SW Loveland, CO 80537 (303) 667-5000	\$2,100/student	Sandy Selleck
Model DTS-70	January 19 - 23 March 9 - 13 May 18 - 22 July 20 - 24 September 28 - October 2 November 16 - 20	Loveland Instrument Division	\$1,000/student	Sandy Selleck
Technology Training				
Digital Troubleshooting Techniques	March 17 - 20 May 12 - 15	Instrument Service Center 333 Logue Avenue Mountain View, CA 94043 (415) 968-9200	\$ 350/student	Debra Conley
Microprocessor Troubleshooting Techniques	March 23 - 26 May 18 - 21	Instrument Service Center	\$ 350/student	Debra Conley
HPIB Fundamentals for Service Technicians	January 28 April 6 September 28	Instrument Service Center	\$ 200/student	Debra Conley
DSA/Laser				
Fourier Systems & Maintenance Models 5451C/5427A	October 5 - 9	Santa Clara Division 5301 Stevens Creek Blvd. Santa Clara, CA 95050 (408) 246-4300	\$ 700/student	Marshall Lollis
Microwave Instruments				
8671A Microwave Frequency Synthesizer	August 31 - September 4	Stanford Park Division 1501 Page Mill Road Palo Alto, CA 94304 (415) 857-2980	\$ 400/student	Steve Thomas
8672A Synthesized Signal Generator				
436A Power Meter				
Klystron Generators				
8660 & 8662 Synthesized Signal Generators	October 5 - 8	Spokane Division 1620 Signal Drive Spokane, Washington 99220 (509) 922-4001	\$ 350/student	Rodger Tracy
8640 AM/FM Signal Generator	September 28 - October 2	Spokane Division	\$ 400/student	Rodger Tracy
8903A Audio Analyzer				
8901A Modulation Analyzer				
Signal Analysis				
Models 8566A Microwave/8568A Programmable	February 23 - 27 September 14 - 18	Santa Rosa Division 1400 Fountain Grove Parkway Santa Rosa, CA 95404 (707) 525-1400	\$ 400/student	Jim Boyer
8565A Spectrum Analyzer	November 2 - 6	Santa Rosa Division	\$ 350/student	Jim Boyer

READERS' CORNER

Converting Incident and Reflected dBm Readings To VSWR With an HP 25

Dear Sir:

I am currently working with the HP network analyzer here at NAS Whidbey Island Calibration Lab. I thought you might be interested in a program for the HP 25 I have developed for converting incident and reflected dBm readings directly to VSWR. With incident and reflected power in watts, and reflection coefficient magnitude and return loss readily available in various memory locations. I find this easier and more accurate than the standard nomograph.

Douglas Hoyer
 NAS Calibration Lab
 Naval Air Station
 Whidbey Island, WA

store incident dBm in memory location 1
 store reflected dBm in memory location 2

```

1 00
2 23 04 store 4
3 24 01 recall 1
4 01
5 00
6 71
7 15 08 G 10x
8 73
9 00 0
10 05 5
11 61 x
12 05 5
13 00 0
14 71 ÷
    
```

$$.05 \text{ Log}^{-1} \frac{\text{dBm}}{10} = \frac{\text{Power in watts}}{50}$$

```

15 24 04 recall 4
16 15 71 G x=0
17 13 35 go to 35
18 21 exchange x & y
19 23 05 store 5 (reflected power)
20 24 04 recall 4 (incident power)
21 71 ÷
22 14 02 F √x
23 23 06 store 6
24 01 1
25 51 +
26 23 07 store 7
27 24 01 recall 1
28 24 06 recall 6
29 41 -
30 23 03 store 3
31 24 07 recall 7
32 24 03 recall 3
33 71 ÷
34 74 RUN/STOP
35 21 exchange x & y
36 23 04 store 4
37 24 02 recall 2
38 13 04 go to 04
    
```

reflection coef. magnitude =

$$|\rho| = \sqrt{\frac{P_r}{P_i}}$$

$$\text{VSWR} = \frac{1 + \rho}{1 - \rho}$$

When the program stops:
 display = VSWR

- 6 = reflection coefficient
- 4 = absolute incident power in watts
- 5 = absolute reflected power in watts

The 1980 Service Note Index is Now Available

The Service Note Index is a compilation of all the service notes listed to date in *Bench Briefs*.

It is available free of charge from your local HP sales or service office as HP part number 5952-0102, or you can use the order form at the rear of *Bench Briefs*.

Do You Suffer From Intermittents, Noise, or Sudden Level Changes?

The next time you are looking for these particular problems in your instrument, try checking board-to-board connectors. Many times the connector crimp around the wire deteriorates with age and needs to be soldered to regain continuity. If the connector is gold be careful not to get any solder on the inside mating surface.

Want to Save \$\$\$ on Instrument Repairs??

It is a policy of Hewlett-Packard to continually improve the serviceability of HP products. One such program involves providing customers (including HP's Instrument Service Centers), the opportunity to replace defective assemblies with rebuilt at a significant price reduction compared to the list price of a new assembly. This program provides our customers a viable alternative to time-consuming troubleshooting to the component level. Another benefit is reduced down-time for more efficient utilization of the instrument. Each assembly that qualifies for exchange is listed in the instrument's Operating and Service Manual.

So the next time you have a problem, contact your local HP office and inquire about the assembly exchange program — it could save you a lot of time and money.

If you want service notes, please check the appropriate boxes below and return this form separately to one of the following addresses.

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| <input type="checkbox"/> 339A-5 | <input type="checkbox"/> 1640A-8A | <input type="checkbox"/> 3770B-22 | <input type="checkbox"/> 5342A-20 | <input type="checkbox"/> 7047A-4 | <input type="checkbox"/> 64203A-2 |
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