HEWLETT-PACKARD INTERFACE BUS

PROGRAMMING HINTS

for systems based on the HP 9825A Desktop Computer

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INTRODUCTION

In addition to the manuals that you received with your 9825A or 9830A/B desktop computer you may find this Programming Guide helpful if you are a beginning programmer or just starting to work with the Hewlett Packard Interface Bus (HP-IB).

In this User's Guide you will find a wide variety of tested examples. In addition you will find several helpful workshop problems along with their answers. The programming examples are built up around the following popular HP-IB instruments.

3438A	DMM
3455A	DVM
3437A	Systems DVM
3495A	Scanner
5328A	Universal Counter
5345A	Plug-In Counter
5340A	Microwave Counter
59309A	Digital Clock
59307A	VHF Switch
59306A	Relay Actuator
3571A	Spectrum Analyzer
59501A	D/A Power Supply Programmer
59308A	Timing Generator
3330B	Frequency Synthesizer
59304A	Numeric Display
9871A	Printer Plotter
9825A	Desktop Computer
9830A/B	Desktop Computer
59403A	Common Carrier Interface

Chapter 1
GETTING STARTED

This book is designed to help you connect many popular instruments and program a 9825A or 9830A/B computing controller for use with the Hewlett-Packard Interface Bus (HP-IB). The procedure for interconnecting an HP-IB system is really quite simple if you follow an orderly approach:

1. Gather the equipment — make sure that the instruments and controller are turned off.
2. Install the necessary plug-in cards and ROMS.
3. Set the appropriate device address switches (if they need to be changed).
4. Physically connect the cables.
5. Turn equipment on, and program the controller.

The first four steps will take approximately 5 or 10 minutes — it's as easy as assembling stereo components. Step 5, generating programs, takes longer; hence, most of this book will be devoted to software. Starting with the next chapter, this text provides program instructions for activating several common HP instruments and, in some cases, we've included simple application programs as examples. But first, let's assemble the system hardware.

Equipment

Typically, the following equipment comprises an HP-IB system:

- HP 9825A or 9830A/B programmable desktop computer.
- Bus interface cables — 0.5, 1, 2, or 4 metres in length.
- Bus-compatible instruments and devices (up to 14) — Each device must include all options and accessories necessary for HP-IB operation.
- Plug-in interface cards and ROMs.

CARDS AND ROMS

For the 9825A, you will need: 1) the 98034A Bus Interface Card, and 2) the General I/O ROM which contains a common set of bus messages. With the General I/O ROM, you have limited HP-IB capabilities whenever you turn on the 9825A. An extended I/O ROM combined with the General I/O module is also available which allows total HP-IB capability, plus several other additional features. None of these plug-ins are factory-installed.

For the 9830A/B, you need: 1) the 59405A Bus Interface I/O card which outputs to the interface bus; 2) the 11272B Extended I/O ROM which contains the bus commands in addition to other capabilities; and 3) optionally, the 11274B String Variable ROM which simplifies programming. Any of the ROM's can be factory-installed if you so specify.

To install the Bus Interface Card, first make sure that the 9825A or 9830A/B is turned off, then insert the interface card, in any I/O slot on the rear panel of the computer. To install the 9825A ROMs, slide the card (ROM label right-side-up) into any of the four front slots below the keyboard. To field install the 9830A/B ROMs, open the door on the lower left side of the computer and insert the card or cards into any one of the slots (figure 1-2).

Setting Addresses

The next step is to assign DEVICE addresses to each device to be used on the interface bus. Every instrument, controller, peripheral, or accessory *must* have an identifying code. The address in an HP-IB system is just like your phone number in the telephone system — it is a unique means of access by which a message can be sent to or from a specific device.

A word of advice: it is considerably easier if you set the instrument address switches *before* connecting all the equipment. Most HP-IB devices have small address switches on the rear panel (figure 1-4) and you simply set each switch to the appropriate position, 1 or 0. If the device address was preset at the factory, you may want to leave it as is — however, you can override it simply by setting the rear panel switches (or internal jumpers) to a different address. The Bus Interface Card for each computing controller comes with preset (but changeable) talk and listen addresses, so there is no need to set them. (Controller addresses will be discussed later.)

An HP-IB address consists of a 7-bit binary code, as follows:

Bit Position:	b_7	b_6	b_5	b_4	b_3	b_2	b_1
	Operating Mode		Device Address				

The two bits on the left (b_7 and b_6) specify the instrument's operating mode — whether it will output data (talk) only, receive data (listen) only, or whether the device is addressable (programmable talk and/or listen).

For systems that contain a controller such as a desktop computer each HP-IB device must be set to ADDRESSABLE. Many instruments have either a switch labelled ADDRESSABLE on the back of the instrument (figure 1-5), or an instruction plate on the bottom of the instrument that illustrates switch settings. (The alternative operating mode will be TALK ONLY or LISTEN ONLY, depending on whether the device primarily sends or receives data.)

The bit positions b_1 through b_5 refer to ASCII characters (represented by a binary code) that specify the device address. Table 1-1 lists all permissible address codes that may be used on the interface bus.

Notice that the two computing controllers handle addresses differently. The 9830A/B computer uses typewriter symbols as addresses, while the 9825A uses two-digit numbers. Also, the 9830A/B differentiates between talk and listen addresses in its programming, but the hardware switch settings are the same for both addresses. This may seem confusing, so let's take an example. The 3455A Multimeter is preset to an address of 22.

With the 9825A computing controller and using General I/O only the same two-digit number is used for addressing, regardless of the instrument's function. A 9825A address must always contain two digits. If the 5-bit value is a one-digit number (e.g., 9), a leading zero must be used (e.g., 09).

If the numerical address is the same, how then does the 9825A specify whether a device is to talk or listen in its program instructions? As you will learn in the following chapters, "read" and "write" commands are usually used to dictate the function of the addressed instrument.

Incidentally, the two-digit address is not an arbitrary number. Given the address switch positions or 9830A/B talk and listen device addresses, you can figure the numerical address to be used with the 9825A. Let each bit position represent a power of 2 as follows:

Bit positions:	b_5	b_4	b_3	b_2	b_1
Binary weighting:	2^4	2^3	2^2	2^1	2^0
Decimal value:	16	8	4	2	1

Table 1-1. Allowable Address Codes

Address Switches					9830A/B Talk Address Character	9830A/B Listen Address Character	9825A* Address Numbers (5 Bit Decimal Value)
A_5	A_4	A_3	A_2	A_1			
0	0	0	0	0	@	SP	00
0	0	0	0	1	A	!	01
0	0	0	1	0	B	"	02
0	0	0	1	1	C	#	03
0	0	1	0	0	D	$	04
0	0	1	0	1	E	%	05
0	0	1	1	0	F	&	06
0	0	1	1	1	G	'	07
0	1	0	0	0	H	(	08
0	1	0	0	1	I	)	09
0	1	0	1	0	J	*	10
0	1	0	1	1	K	+	11
0	1	1	0	0	L	,	12
0	1	1	0	1	M	−	13
0	1	1	1	0	N	.	14
0	1	1	1	1	O	/	15
1	0	0	0	0	P	0	16
1	0	0	0	1	Q	1	17
1	0	0	1	0	R	2	18
1	0	0	1	1	S	3	19
1	0	1	0	0	T	4	20
** 1	0	1	0	1	U	5	21
1	0	1	1	0	V	6	22
1	0	1	1	1	W	7	23
1	1	0	0	0	X	8	24
1	1	0	0	1	Y	9	25
1	1	0	1	0	Z	:	26
1	1	0	1	1	[	;	27
1	1	1	0	0	\	<	28
1	1	1	0	1	]	=	29
1	1	1	1	0	^	>	30

* The "9825A" address numbers are the 5 bit decimal equivalents of TALK/LISTEN characters — see page 1-5.
**Computer interface card, factory-set TALK/LISTEN address (not advisable for use as an instrument address).

The device address is the sum of the numerical values according to the bits set. Using the 3455A multimeter again, assume the switch settings are:

1	0	1	1	0
16	0	4	2	0

Adding the decimal values of the set bits, 16 + 0 + 4 + 2 = 22, we find that the 3455A multimeter will have an address of 22 when used with the 9825A computing controller.

Admittedly, you don't have to stop and calculate the address for each HP-IB device. Simply use Table 1-1 as a quick, convenient reference. Note also that these switch settings give a talk address of V and a listen address of 6. Therefore for 9830A/B programming:

	9830A/B Talk Address	9830A/B Listen Address
3455A Multimeter	V	6

Consulting Table 1-1, we find that the address switch setting for both V and 6 is:

A_5	A_4	A_3	A_2	A_1
1	0	1	1	0

One setting on the device specifies both addresses; however, the 9830A/B program instructions will differentiate between the two addresses — the 9830A/B will specify V or 6, depending on whether the multimeter is to talk or listen. Bits A_6 and A_7 are *electrically* set to differentiate as to whether it will be a talker or listener.

Computer Talk and Listen Addresses

Both the 9830A/B and the 9825A computers (actually the computer interface cards) are factory-set to an address of 21 (talk address, U and listen address, 5). All examples in this book use these standard addresses, so do NOT assign these to any other HP-IB device.

Multiple Addresses

HP-IB devices that communicate with each other as well as with the computing controller may have two talk addresses or two listen addresses. For example, an instrument may use one listen address to receive program instructions from the controller and a second listen address to receive measurement data from another instrument.

The device address is the sum of the numerical values according to the bits set. Using the 3455A multimeter again, assume the switch settings are:

1	0	1	1	0
16	0	4	2	0

Adding the decimal values of the set bits, 16 + 0 + 4 + 2 = 22, we find that the 3455A multimeter will have an address of 22 when used with the 9825A computing controller.

Admittedly, you don't have to stop and calculate the address for each HP-IB device. Simply use Table 1-1 as a quick, convenient reference. Note also that these switch settings give a talk address of V and a listen address of 6. Therefore for 9830A/B programming:

	9830A/B Talk Address	9830A/B Listen Address
3455A Multimeter	V	6

Consulting Table 1-1, we find that the address switch setting for both V and 6 is:

A_5	A_4	A_3	A_2	A_1
1	0	1	1	0

One setting on the device specifies both addresses; however, the 9830A/B program instructions will differentiate between the two addresses — the 9830A/B will specify V or 6, depending on whether the multimeter is to talk or listen. Bits A_6 and A_7 are *electrically* set to differentiate as to whether it will be a talker or listener.

Computer Talk and Listen Addresses

Both the 9830A/B and the 9825A computers (actually the computer interface cards) are factory-set to an address of 21 (talk address, U and listen address, 5). All examples in this book use these standard addresses, so do NOT assign these to any other HP-IB device.

Multiple Addresses

HP-IB devices that communicate with each other as well as with the computing controller may have two talk addresses or two listen addresses. For example, an instrument may use one listen address to receive program instructions from the controller and a second listen address to receive measurement data from another instrument.

Multiple-address devices have a different set of address switches on the rear panel — usually just four switches. A single setting will determine two talk addresses and two listen addresses. The four switches control the A_2 through A_5 positions listed in Table 1-1. (There is no switch for A_1.) For example, setting these switches to:

A_5	A_4	A_3	A_2
1	0	0	1

produces two listen addresses of "2" and "3" with two corresponding talk addresses of "R" and "S" (18 and 19 on the 9825A).

Address Table

It's a good idea to write down the address for each HP-IB device as you set it. This way, you will avoid duplication and will have all address codes handy when you start programming the system.

CONNECTING BUS CABLES

You may interconnect the system elements in almost any order or any configuration, as long as there is a path from the computing controller to every HP-IB device.

The cable connectors can be stacked one on another; up to 3 or 4 cables on any one connector. If the stack gets too long, the leverage could damage the connector's mounting.

The cable length must be the lesser of:

- Two meters ($\sim$ 6 feet) times the total number of system devices. (Be sure to count the controller.)
  or
- 20 meters total

These restrictions are rigorous. For example, if the system cable length is too long, the bus interface cannot properly drive the lines to achieve specified performance.

This completes the procedure for system assembly. Now you're ready to turn on the equipment and start programming.

Chapter 2
PROGRAMMING COMMANDS

Many HP-IB users have had experience with the HP 9830A/B desktop computer and are moving on to the more powerful and faster 9825A. This chapter is intended to help you understand 9825A HP-IB programming and how it differs from the 9830 A/B programming.

For example, statements and commands, eg: CMD, are uppercase in the 9830A/B, lower case and usually abbreviated to three letters in the 9825A, eg: wrt, red, cmd.

The 9830A/B uses command, enter and output statements for HP-IB operations while the 9825A usually uses read and write statements (abbreviated red and wrt).

Address information is handled quite differently between the two computers. Both computers have 5 bit, factory set, decimal addresses of 21 (ASCII U/5). The 9830A/B uses ASCII codes (typewriter symbols) as address information. The 9825A uses decimal values (numbers) as address information. The 9825A HP-IB interface card (98034A) has a screwdriver switch which allows the select code address of the interface card to be changed. The adjustable address of the card is factory set to 7. Therefore, all bus statements on the 9825A starting with the number 7, eg: cmd 7, "U6" would make interface card 7, in this case the 9825A, a talker and instrument "6" a listener.[1]

The 9830A has address number 13 hardwired as the bus interface select code address. This number shows up in output and enter statements and cannot be changed easily.

Let's take the 3455A DVM as an example. The 3455A can be both a talker (send reading to computer) and a listener (receive range and function information from the computer). Assume we want to send the message F2R3T1 to the 3455A and then take a reading into

[1]To use the cmd statement, the Extended I/O ROM must be installed.

variable X. The 5 bit address of the DVM (set on switches on the back) is 22 (ASCII V/6), see Table 1-1. When working with the 9825A, the "22" address is used with red and wrt statements. V/6 is used with cmd statements and when working with the 9830A/B.

On the 9825A this operation would be:

```
0:      wrt 722, "F2R3T1"
1:      red 722, X
```

Program line numbers

On the 9830A/B this same operation would be:

```
10      CMD "?U6","F2R3T1"
20      FORMAT F10.4
30      CMD "?V5"
40      ENTER (13,20)X
```

Range Function and Trigger Commands (see 3455A Manual)

DVM listen

Computer talk

Unlisten

10 digit wide field with 4 digits to the right of the decimal point

Computer listen

DVM talk

As described in format line 20 via select code 13

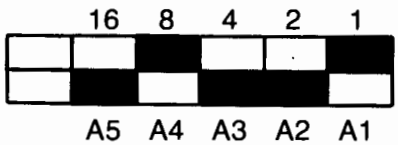
This is the interface card

Program line numbers

ASCII CHARACTER		5 BIT DECIMAL VALUE
TALK	LISTEN	
@	SP	00
A	!	01
B	"	02
C	#	03
D	$	04
E	%	05
F	&	06
G	'	07
H	(	08
I	)	09
J	*	10
K	+	11
L	,	12
M	-	13
N	.	14
O	/	15

	ASCII CHARACTER		5 BIT DECIMAL VALUE
	TALK	LISTEN	
	P	0	16
	Q	1	17
	R	2	18
	S	3	19
	T	4	20
*	U	5	21
	V	6	22
	W	7	23
	X	8	24
	Y	9	25
	Z	:	26
	[	;	27
	\	<	28
	]	=	29
	^	>	30

Example Address
SWITCH ON REAR
OF INSTRUMENT



*Preset computer
1 interface card
0 TALK/LISTEN address

A5 is (0) (16) = 0
A4 is (1) (8) = 8
A3 is (0) (4) = 0
A2 is (0) (2) = 0
A1 is (1) (1) = 1
Sum = 9

EXAMPLE:
red 709 or wrt 709 on 9825A
CMD "I5" or CMD "U)" on 9830A/B

Table 2-1. ASCII Characters and their 5 Bit Equivalents

Additional commands: the semicolon in 9830A/B programs supresses CR/LF

9830A/B	**9825A**
SET LOCAL:	lcl7

10 CMD "?U" necessary to set 9830A/B as "talker" to properly OUTPUT line 30.

20 FORMAT B

30 OUTPUT (13,20)1024; Note the 20 refers to the FORMAT statement in line 20.

SET REMOTE (This command is *not* necessary on 9825 or 9830A/B unless the bus has previously been programmed to local. The "POWER UP" or "RESET" condition sets the REN line to remote). In this condition REN is TRUE. Even though this line is set TRUE during power up *it is wise* to always begin programs with this SET REMOTE Command. Also, it must also be executed to return to bus operation after a SET LOCAL command has been issued.

9830A/B	**9825A**
10 CMD "?U"	rem 7
20 FORMAT B	
30 OUTPUT (13,20)768;	

INTERFACE CLEAR

9830A/B	**9825A**
PUSH STOP key	Push reset or program cli 7

UNLISTEN

9830A/B	**9825A**
10 CMD "?"	Happens automatically in red & wrt statements

The following are *universal* commands and use a 3 number output format on the 9830A/B as follows:

9830A/B

```
10  CMD "?U"          ──────►Puts 9830A/B into Command Mode (using FORMAT B)
20  FORMAT 3B                ┌►out of Command Mode back into Data Mode
30  OUTPUT (13,20)256, <number>, 512;
              ▲
              └HP-IB
                select code
```

LOCAL LOCKOUT:	**9825A**
17	llo7
DEVICE CLEAR:	
20	clr 7
SERIAL POLL ENABLE:	
24	not necessary
SERIAL POLL DISABLE:	
25	not necessary

Example:

30 OUTPUT (13,20)256,20,512;
sends the **DEVICE CLEAR MESSAGE**

The following commands require the *specific address* of a device.

Example uses address 22 (ASCII 6 in 9830A/B)

9830A/B

```
10  CMD "U6"
20  FORMAT 3B
30  OUTPUT (13,20)256, <number>,512
```

GO TO LOCAL	**9825A**
1	lcl 722
SELECTED DEVICE CLEAR	
4	clr 722
GROUP EXECUTE TRIGGER	
8	trg 7 or trg 722 (to a selected device)

CHECKING BUS STATUS; STARTING A POLL; POLLING; ENDING A POLL.

9830A/B **9825A**

```
10  A = STAT 13        (checks interface card, bit 7,
                        to see if SRQ has been pulled)      0: rds (7)→X

20  CMD "?U"                                                1: if bit (7, X); gto "SRQ"
                                  calculator — LISTEN
30  FORMAT 5B                          device — TALK
                                                                    :
40  OUTPUT (13,30)256, 95, 53, 24, 512;                     10: "SRQ": rds (722)→X
                                  serial poll "enable"

50  CMD "V" (note the "?" must not be used. This is the "poll" of device V)

60  A = RBYTE 13 (status of instrument V is put into variable A)

70  CMD "?U"

80  FORMAT 3B                          serial poll "disable"

90  OUTPUT (13,80)256, 25, 512;
```

Providing the Extended I/O ROM is installed, the command statement (cmd) can be used with the 9825A, but it is not necessary. Simple red and wrt statements are sufficient.

If it is desired to have one device talk directly to another without the computer buffering the interchange, the command statement can be used. Example with the 9825A:
cmd 7, "?P8"
This causes device P (ASCII 16 — possibly the 59309A ASCII clock) to talk directly to device 8 (ASCII 24 — possibly the 59304A Numeric Display).

In the 9830A/B, the command statement toggles between address and data with every comma. The 9825A cmd statement does not do this.

For example, in the 9830A/B, line 20: CMD "?U6", "R7F2", "?U)","17" would program device 22 (ASCII 6) and 09 (ASCII)). The 9825A would require two cmd statements: cmd7,"?U6", "R7F2";cmd7,"?U)","17"

Chapter 3
PROGRAMMING MEASUREMENT INSTRUMENTS

The largest block of HP-IB instruments presently available is the measurement instrument group. This chapter will give you programming details on 11 highly popular HP-IB products.

3455 DVM	59306A Universal Switch
3437A Systems DVM	3571A Spectrum Analyzer
3438A Digital Multimeter	5328A Universal Counter
3495A Scanner	5340A Microwave Counter
59309A Digital Clock	5345A Plug-In Counter
59307A UHF Switch	

USE OF THE "time", "trg", "on err", "rom", "ern", "erl" STATEMENTS

These powerful statements have wide use with many measurement devices, and will be discussed as a group before moving on to specific instruments.

When instruments such as counters are used in a system where automatic operation is desired, a problem will sometimes arise when a frequency or period measurement is initiated from the controller and the signal is not present or is of such a low level that the counter is not triggered. The controller will stop at the "red" instruction forever, waiting for the measurement to be completed. This action will stop the system from doing anything else. A useful set of instructions in the 9825A are available to help solve this problem.

THE "time" STATEMENT. If a time 1000 is executed at the start of the program, the computer will give an error E4 whenever it takes longer than 1000 milliseconds to complete an I/O operation (the range of the wait before error is 1 ms to 32 sec).

THE "trg" STATEMENT. This statement can be used to trigger one instrument or several instruments; trg 7 triggers all instruments which respond, trg 710 triggers only device 10.

THE "on err" STATEMENT. This statement allows branching to a label whenever an error occurs in the computer.

THE "rom" STATEMENT. This statement gives the ASCII character decimal equivalent of the ROM letter in which the error occurred. For example, "E" (as in Extended I/O) has a decimal equivalent of 69.

The "ern" statement gives the number of the error that occurred.

The "erl" statement gives the number of the line in which the error occurred.

The following program shows how these instructions might be used to alert the operator that a counter was not being triggered.

```
0: time 3000
1: on err "ERROR"
2: wrt 710,"PF4G6R"    — Set 5328A to measure frequency
3: trg 710;red 710,X   — Trigger and read 5328A
4: dsp X  — Display result
5: gto 3
6: end
7: "ERROR":
8: rom→A;ern→B;erl→C
9: if A=69 and B=4 and C=3;beep;prt "Counter Problem"
10: fxd 0;dsp "ERROR",char(A),B,"in line",C
```

3455A DVM

The 3455A is one of the most straight forward instruments to program and read on the bus that is available at this time. It will serve as an example for other discussions.

Table 3-1. 3455A HP-IB Program Codes

	Control	Program Code
FUNCTION	DC Volts	F1
	AC Volts	F2
	Fast AC Volts	F3
	2 Wire kΩ	F4
	4 Wire kΩ	F5
	Test	F6
RANGE	.1	R1
	1	R2
	10	R3
	100	R4
	1 K	R5
	10 K	R6
	AUTO	R7
TRIGGER	Internal	T1
	External	T2
	Hold/Manual	T3
MATH	Scale	M1
	Error	M2
	Off	M3
ENTER	Y	EY
	Z	EZ
STORE	Y	SY
	Z	SZ
AUTO CAL	Off	AØ
	On	A1
HIGH RESOLUTION	Off	HØ
	On	H1
DATA READY RQS	Off	DØ
	On	D1
BINARY PROGRAM		B

The 5 bit decimal address 22, which corresponds to V/6, is often used as the 3455A talk/listen address. The first letter of each word describing a logical group of buttons on the device is underlined. To "push a button" under software control, the first letter of the logical group is sent, followed by the number representing the position of the button in that group. There are no delimiters between commands. For example "F2R7" sets AC volts and autorange. Trigger mode T1 (internal trigger) should not be used for bus operations to ensure the proper reading is taken. Instead, trigger mode "T2T3" should be used. To read the voltmeter the trigger command is given (trg 722) followed by a simple read (red 722), followed by a comma and then the variable name. See line 1 in the example program. After the first reading is taken a trigger command can be used for each successive reading. Example using the 9825A. (Note this would also work if only GEN I/O and not EXT I/O were present.)

In this example a DC voltage is read into variable X and the results are displayed.

```
0: wrt 722,"F1R7T2T3"
1: trg 722;red 722,X
2: fxd 6;dsp X
```

The fxd 6 assures all digits show up in the displayed result.

To make 50 readings and average the result the following program can be used:

```
0: wrt 722,"F1R7T2T3"
1: for I=1 to 50
2: trg 722;red 722,X
3: X+S→S
4: next I
5: fxd 6;dsp S/50
```

(at turn on all variables, e.g., X, S, are initialized to zero)

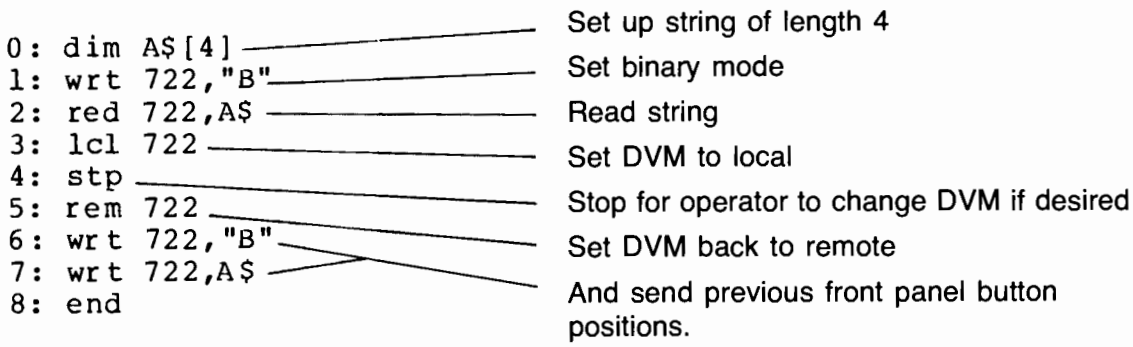
If manual or external triggering is used, the time interval between readings may be so long that the computer may be wasting time waiting for a reading. The DVM can "interrupt" the computer when a reading is completed and have the computer make the reading. This is called "Data Ready Request Service". To use this feature, the command "D1" is given to the 3455A. The following program demonstrates this capability.

```
0: oni 7,"READ"
1: wrt 722,"F1R7T2T3D1"
2: lcl 722
3: wait 500
4: eir 7
5: "AGAIN":dsp I
6: wait 100
7: 1+I→I
8: gto "AGAIN"
9: stp
10: "READ":
11: red 722,X
12: dsp X;wait 1000
13: eir 7;iret
14: end
```

When an interrupt occurs, go to subroutine "READ"
SET DR RQS mode manual trigger
Put 3455A into local so HOLD/MANUAL button can be pushed.
Enable interrupt
Display an incremented variable
Wait to increment
Increment variable
Repeat
Stop if pgm gets here
Subroutine label read (Note: A label can also be used for remarks)
Read DVM
Display DC reading for 1 sec
Re-enable interrupt and return

To speed up readings, AUTO CAL may be turned off during fast reads. This is done by programming wrt 722, "AØ". It can be turned back on by "A1".

The 3455A also has what is called "learn mode". This allows the front panel switch positions to be learned by the computer so that the same setup can be repeated later. This is done by sending "B" for binary program.



3437A SYSTEMS VOLTMETER

The 3437A voltmeter is a 3 1/2 digit DC voltmeter capable of high speed operation. The delay between reading may also be programmed up to 1 second long. Normally it is desired to read the meter at a high rate of speed which requires use of buffers in the 9825A.

To program the 3437A so that it works as a normal "bench top" voltmeter making one reading at a time might require: 10 volt range, INTERNAL trigger and ASCII format. This would be accomplished by:

```
0: wrt 724,"R3T1F1"
```

Switch positions are similar to those of the 3455A.

To read the 3437A:

```
0: red 724,X
```

When using HOLD MANUAL Trigger or EXTERNAL Trigger, a delay of up to 1 second can be programmed so that the reading will be made with some delay after the trigger. For example, if it is desired to program a delay of 0.9 seconds, program

```
0: wrt 724,"D.9SN1S"
```

The number of readings in this case must be 1 or else a reading will be made immediately upon receiving the trigger. The 3437A can be programmed to set the SRQ line on the bus when a reading is ready (or for other reasons such as invalid program code sent to it or it did not send data to the computer when a trigger was received, or all of these). The 3455A has a similar mode which is covered in the 3455A writeup. The following program will allow the voltmeter to interrupt the computer when service request is set (SRQ pulled). The program sets the bus to remote and tells the computer to go to label "SRQ" when a bus interrupt occurs. The voltmeter is then set to a delay after trigger of .03 sec, make 1 reading on each trigger, to enable SRQ(allow SRQ) if an invalid program occurs or if data is ready. The bus is then put into local allowing the HOLD/MAN button to be pushed, causing an interrupt. The computer displays an incremented variable over and over.

When SRQ is pulled, the program branches to label SRQ. The bus is set back to remote and a serial poll on the voltmeter is performed and if the reason for the SRQ was data ready, the voltmeter is read. If the reason for the SRQ was invalid program, "invalid program" is printed. The interrupt system is re-enabled and the program continues displaying the incremented variable.

```
0: oni 7,"SRQ";rem 7
1: wrt 724,"D.03SN1SE5SR3T3F1"
2: lcl 7
3: eir 7
4: dsp I+1→I;jmp 0
5: "SRQ":rem 7
6: rds(724)→S
7: if bit(5,S);red 724,X;prt X
8: if bit(3,S);prt "INVALID PGM"
9: eir 7
10: iret
```

To take full advantage of the speed of the 3437A, I/O buffers can be used.

The following example uses an interrupt buffer to make N readings in the ASCII Format (unpacked) with a .9 sec delay between readings. The interrupt buffer is specified with the parameter 1 in line 2.

```
0: "3437 int/buf":
1: ent "No of readings",N
2: buf "LOU",7*N+2,1
3: fmt 1,"D.9SN",f5.0,"SE0SR3T1F1";wrt 724.1,N
4: tfr 724,"LOU"
5: dsp I+1→I
6: if rds("LOU")=-1;jmp -1
7: fmt 2,f,z;for I=1 to N;red "LOU.2",X;prt X;next I
8: spc 1
```

The following example uses a fast read write buffer which will operate faster than the interrupt buffer. The delay is specified by the operator. The fast read write mode is specified by parameter 3 in line 2. The fast read write buffer requires the computer's full attention. Notice the value for I in line 5 does not change as the program is run.

```
0: "3437 burst":
1: ent "No of readings",N,"Delay (>.0006)",D
2: buf "LOU",7*N+2,3
3: fmt 1,"D",f.7,"SN",f5.0,"SE0SR3T1F1";wrt 724.1,D,N
4: tfr 724,"LOU"
5: dsp I+1→I
6: if rds("LOU")=-1;jmp -1
7: fmt 2,f,z;for I=1 to N;red "LOU.2",X;prt X;next I
8: spc 1
9: end
```

3438A DIGITAL MULTIMETER

The 3438A Digital Multimeter is a low cost 3 1/2 digit talk only multimeter, capable of about 4 readings per second on DC volts. It can also measure AC volts, DC and AC current, and ohms. It should be triggered first using the GET statement "trg" followed by a red statement. The device sends back both the reading and also the function selected by the operator from the front panel. The front panel shows that it has a LISTEN function on HP-IB, but this refers only to its listening for a trigger statement. It sends back the reading in scientific notation followed by a comma and then the function as a single digit. Therefore, it should always be read into two variables, even if the function is not desired.

EXAMPLE:

```
0: trg 723;red 723,X,F
```

will read the function into variable F and the actual reading into variable X.

The function can be decoded as follows:

1 = DCV

2 = ACV

3 = DCA

4 = ACA

5 = OHM

If it is desired to display the function that the 3438A is set to, use the following program:

```
0: rem 723;fxd 6;dim A$[88]
1: trg 723;red 723,X,F
2: if F=1;"DC VOLTS"→A$
3: if F=2;"AC VOLTS"→A$
4: if F=3;"DC AMPS"→A$
5: if F=4;"AC AMPS"→A$
6: if F=5;"OHMS"→A$
7: dsp X,A$
8: gto 1
```

The 3495A Scanner mainframe can contain 4 decades of 10 each channels. The two types of channels available are called LOW THERMAL and RELAY ACTUATORS. Schematically they look like this:

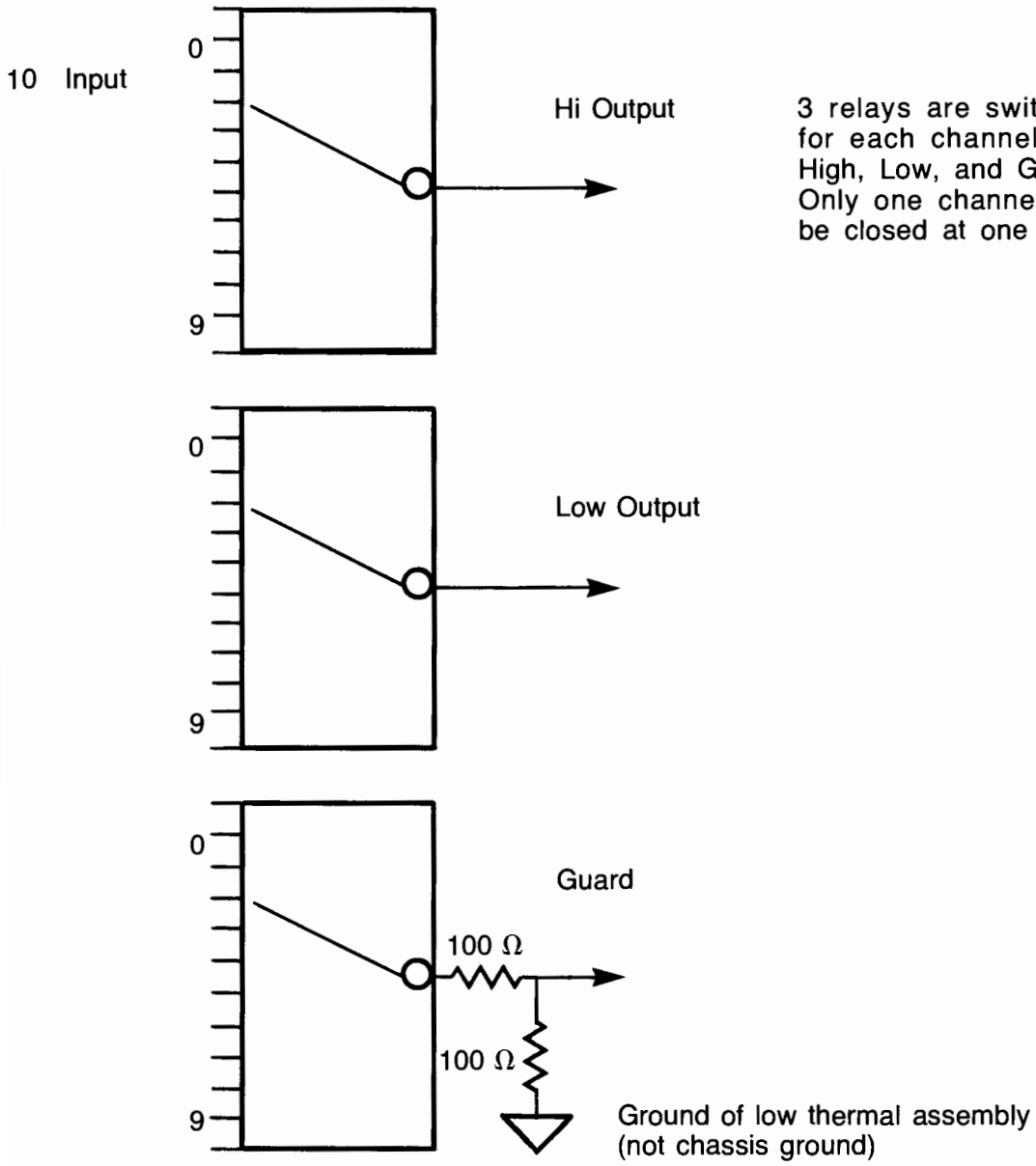


Figure 3-1. One Decade of Low Thermal Channels

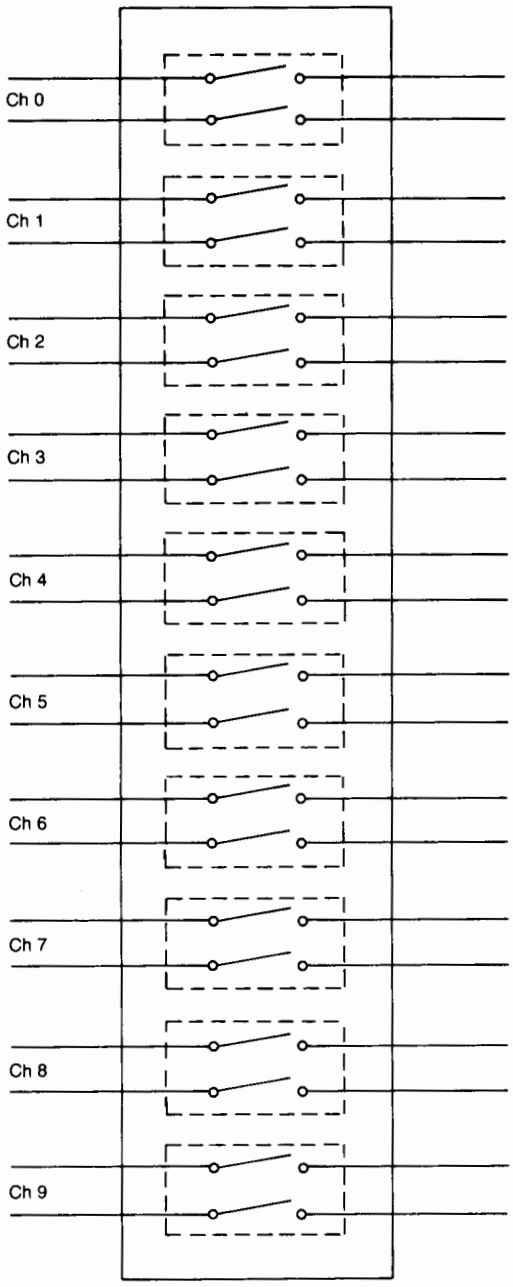


Figure 3-2. Relay Actuator

As many channels as desired can be closed in the same decade at the same time in Relay Actuator decades. Decade information is given by the first digit and channel information by the second digit. For example, 37 would mean Channel 7 in decade 3.

If it is desired to be able to close different channels in different decades at the same time in a low thermal decade, it is necessary to remove some jumpers inside the scanner. To make this modification remove the top cover from the scanner. Remove the "open" jumper packs, which are in IC sockets, from all decades desired.

The device address 09 of the scanner is hardwired inside the mainframe.

Examples of programming:

wrt 709, "07"	Close channel 7 in decade 0 of low thermal or relay actuator

If it is desired to output a variable to a scanner channel a format command should be used to output the variable. For example, to scan channel 0 to 39, the following would be used:

```
0: fmt 1,fz2.0
1: for I=0 to 39
2: wrt 709.1,I
3: next I
```

Format #1 does not suppress leading zeros when it outputs 2 digits. This is needed when you want to close decade 0, channel 7, e.g. 07, without z format the 0 would be replaced by a space.

To open, i.e., clear, all channels send line 4:

```
0:
1:
2:
3:
4: wrt 709,"C"
```

To close channel 5 and 18 with either Relay Actuators or Low Thermals installed and with the above modification made program wrt 709, "0518".

In a relay actuator decade if you wish to open one or more channels without disturbing other channels, send the decade number followed by a comma followed by the decade number and channel number(s) you wish to keep closed.

For example: line 0 of the following program will close channel 20 thru 23. The program will then stop and after pressing (CONTINUE) channel 21 (actually channel 1, decade 2) will open and channel 20, 22, and 23 will stay closed.

```
0: wrt 709,"20212223"
1: stp
2: wrt 709,"2,202223"
```

59309A CLOCK

The clock can be both set and read with the computer. If the clock is reading properly the data which is returned from the clock will have two leading spaces. If the clock has lost track of time through a failure or has lost power without the 9 volt standby battery being installed or external standby power connected it will return a data field with "?" and "space" (␣) as the first two characters. For this reason data from the clock should be read into a string and the first character should be checked to see if it is a space or a "?". The format of the data is:

␣␣DDMMHHMMSS

March 21 at 10:35 a.m. would be

␣␣0321103500 providing the clock's internal data format switches are set to "packed" mode.

The following program will read the clock and check if the reading is ok (clock address is 16)

```
0: dim A$[30]
1: red 716,A$
2: if A$[1,1]="?";gto "ERR"
3: dsp A$;stp
4: dsp A$;stp
5: dsp A$;stp
6: "ERR":beep;wait 500;beep;dsp "CLOCK ERROR, PLEASE RESET"
```

The following program sets the 59309A Digital Clock to the date and time input by the operator.

```
0: "SET 59309A CLOCK":
1: dim A$[20],B$[20],C$[20]
2: ent "ENTER CLOCK SELECT CODE ",r0
3: if r0<701;gto 2
4: if r0>730;gto 2
5: "AGAIN":ent "ENTER DATE & TIME [M/d/h/m/s]",A$
6: wrt r0,"RP"
7: for I=1 to 4
8: A$[1,pos(A$,"/")→P]→B$;A$[P+1]→A$
9: val(B$)→rI
10: next I
11: val(A$)→r5
12: for I=1 to r5;wrt r0,"S";next I
13: for I=1 to r4;wrt r0,"M";next I
14: for I=1 to r3;wrt r0,"H";next I
15: wrt r0,"T"
16: red r0,C$;val(C$[1,4])→M
17: if M=r1;gto "DAY"
18: wrt r0,"D"
19: gto 16
20: "DAY":if r2=1;gto 5
21: for I=1 to r2-1;wrt r0,"D";next I
22: gto "AGAIN"
23: end
```

If you need to update the clock by one or more seconds send wrt 716, "S" (EXECUTE) . Assuming the clock's select code is 716 the "seconds" register will be updated once every time EXECUTE is pressed.

59307A VHF SWITCH

The VHF switch looks schematically as follows:

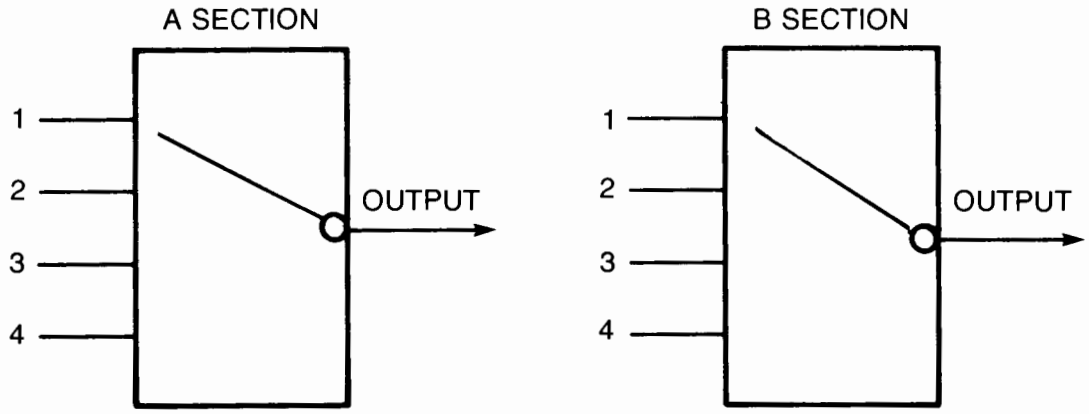


Figure 3-3. VHF Switch

The switch outputs can be connected to one of the 4 inputs.

To close relay 3 in section A and 4 in section B of the VHF switch (device address is 07)

```
0: wrt 707,"A3B4"
```

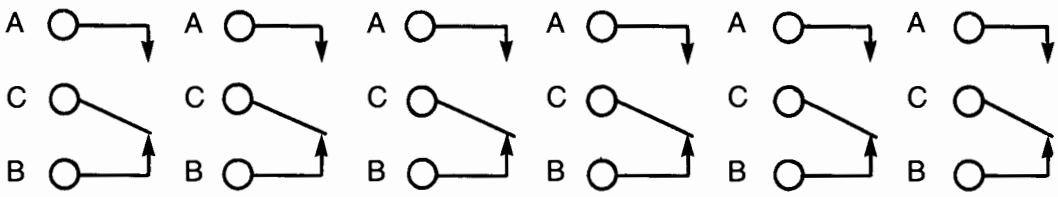
To scan channel 1-4 of section A with a 1 second delay:

```
0: for I=1 to 4
1: fmt "A",f1.0,;wrt 707,I
2: wait 1000
3: next I
4: gto 0
```

Pressing reset on the 9825 or sending lcl 7 will reset the unit to the positions that the front panel buttons are set to. If no buttons are depressed, channel 3 is selected.

59306A RELAY ACTUATOR

The 59306A Relay Actuator contains 6 form C relays that can be controlled via the HP-IB. Schematically the device looks as follows:



To operate the box manually, pushing a button in causes the C contact to be connected to A, leaving the button in the out position connects contact C to B. When a button is in (C to A) the light on that button is on, when it is out the light is off. The relays have a contact rating of .5 amp at 28 V DC or 115 VAC and are Potter and Brumfield NO KA5DG6, HP Part Number 0490-0509.

To control the relays from the bus, use a write statement with the desired switch closures or opens in quotes.

For example to connect C to A in relays one, three and five the command would be (device address is assumed to be 08):

```
0: wrt 708,"A135"
```

To clear relay one and five the command would be

```
0: wrt 708,"B15"
```

To use the devices as a scanner, the C contacts can be wired together and the A contacts connected to the devices to be scanned. To scan all six channels under program control:

```
0: for I=1 to 6
1: fmt 1,"A",f1.0
2: wrt 708.1,I
3: wait 30
4:
5:
6: fmt 2,"B",f1.0
7: wrt 708.2,I
8: next I
9: gto 0
```

for next loop
send A1, A2 etc.
Relays take 30 ms to settle
Measurements done here
Clear the relay

3571A SPECTRUM ANALYZER

The 3571A Spectrum Analyzer requires the 3330A or B or 3320A or B Synthesizer to operate. The 3044A system is a manually operated spectrum analyzer system and the 3045A system is a desktop computer based automatic spectrum analyzer system. Programming the 3571A the 3045A system is well covered in the 3045A software included with the system and is covered in Application note 216.

If the 3571A and synthesizer are used with HP supplied software, the following information will allow the user to operate the 3571A. The 3330B is covered elsewhere in this document. All front panel controls except the power switch and the AMPLITUDE ZERO control can be programmed.

The device address is set inside the unit and is usually set to 17. To program a front panel control locate the ASCII character(s) for the function(s) desired and send the ASCII characters in a wrt statement.

Assuming the synthesizer has been programmed to a frequency thereby tuning the spectrum analyzer, the following example will allow the user to program the spectrum analyzer to make a measurement of the following: Trigger mode: dbm, smoothing: off, bandwidth: 1 kHz, input range: 0 dbm, input impedance: 50 ohm.

```
wrt 717, "M1R0S0B5V6Z0"
wrt 717, "T"; red 717, X; dsp X
end
```

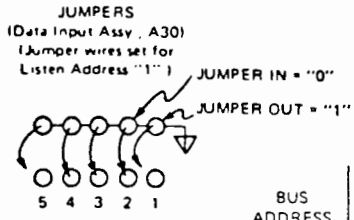
The 3571A outputs a leading character O or N depending on whether the unit is overloaded (O) or has made a normal reading (N). This can be checked by reading the data into a string variable and checking the value of the first character (see 5340A Frequency Counter writeup). The first reading taken from the 3571A when going from local to remote will be in error and should be discarded.

Instructions except numerical offset entries can be entered in any order. For numerical offset entries see text.

The 3571A will respond to HP-IB Unaddress commands but will ignore all Universal and Addressed commands.

The 3571A is shipped from the factory with an ASCII Listen and Talk address of 1 and Q, respectively. The numerical equivalent Bus address is 717. To change addresses, insert or remove appropriate jumpers on data input assembly A30. See illustration.

When the 3571A and the 3330B Automatic Synthesizer are interconnected with the 11236B Multi-Unit Cable and the synthesizer is sweeping, the 3571A receives a measure command from the synthesizer at each sweep step. This measure command completely overrides the internal sampling when the 3571A is in the Auto measurement control mode. When the 3571A is in the External mode, it still responds to the measure commands from the synthesizer. However, it will also respond to an External Trigger command unless it is already making a measurement initiated by the synthesizer.



BUS ADDRESS	ADDRESS CODE 5	4	3	2	1
700	0	0	0	0	0
701	0	0	0	0	1
702	0	0	0	1	0
703	0	0	0	1	1
704	0	0	1	0	0
705	0	0	1	0	1
706	0	0	1	1	0
707	0	0	1	1	1
708	0	1	0	0	0
709	0	1	0	0	1
710	0	1	0	1	0
711	0	1	0	1	1
712	0	1	1	0	0
713	0	1	1	0	1
714	0	1	1	1	0
715	0	1	1	1	1
716	1	0	0	0	0
717	1	0	0	0	1
718	1	0	0	1	0
719	1	0	0	1	1
720	1	0	1	0	0
721	1	0	1	0	1
722	1	0	1	1	0
723	1	0	1	1	1
724	1	1	0	0	0
725	1	1	0	0	1
726	1	1	0	1	0
727	1	1	0	1	1
728	1	1	1	0	0
729	1	1	1	0	1
730	1	1	1	1	0

When the 3571A is in the External mode, the 3330B sweep will be inhibited until the 3571A is addressed to talk.

The 3571A will always accept a talk address but will not actually transmit data unless it is in the External mode and has received an External Trigger command or a measure command from the synthesizer.

OUTPUT Format.

The 9825A can be used to accept measurement data from the 3571A in a form similar to that used for programming. During each output cycle, the 3571A transmits a series or "string" of seven-bit ASCII characters which correspond to the amplitude reading on the front panel display. The format for each output string is as follows:

Character:	N/O	SGN	OR	D4	D3	DP	D2	D1	CR	LF
Order	1	2	3	4	5	6	7	8	9	10

Amplitude readings are transmitted in fixed-point notation exactly as they appear on the front panel display. The order is: Normal/Overload (N/O), Polarity Sign (SGN), Overrange "1" or "0" (OR), D4, D3, Decimal Point (DP), D2 and D1 followed by Carriage Return (CR) and Line Feed (LF).

ASCII Programming Codes
3571A INSTRUCTION CODES

Front Panel Instructions	ASCII Character	Octal Code
ENTER OFFSET:	P	120
DISPLAY REF:		
Relative:	R2	122, 062
dBV:	R1	122, 061
dBm:	R0	122, 060
DISPLAY SMOOTHING:		
On:	S1	123, 061
Off:	S0	123, 061
BANDWIDTH:		
10 kHz:	B7	102, 067
3 kHz:	B6	102, 066
1 kHz:	B5	102, 065
300 Hz:	B4	102, 064
100 Hz:	B3	102, 063
30 Hz:	B2	102, 062
10 Hz:	B1	102, 061
3 Hz:	B0	102, 060
INPUT RANGE:		
+10 dBV:	V7	126, 067
0 dBV:	V6	126, 066
-10 dBV:	V5	126, 065
-20 dBV:	V4	126, 064
-30 dBV:	V3	126, 063
-40 dBV:	V2	126, 062
-50 dBV:	V1	126, 061
-60 dBV:	V0	126, 060
INPUT IMPEDANCE:		
1 Ω, 30 pF:	Z2	132, 062
75 Ω:	Z1	132, 061
50 Ω:	Z0	132, 060
Special Instructions		
MEASUREMENT CONTROL MODE		
Auto:	M0	115, 060
External:	M1	115, 061
EXTERNAL TRIGGER:	T	124
Numerical Offset Entries		
OFFSET PREFACE	O	117
Characters	0-9	060-067, 070, 071
Decimal Point:	.	056
Plus	+	053
Minus	-	055

Figure 3-4. 3571A Programming Summary Sheet

5328A, 5340A, 5345A

The three counters, 5328A, 5340A, and 5345A can use two different modes: **wait until addressed** and **only if addressed.** The difference between these two modes is as follows:

Only if addressed — During the counter's operating algorithm the counter checks to see if it is addressed to talk (a pending read statement in the 9825A). If it hasn't it begins another measurement.

Wait until addressed — During the counter's operating algorithm the counter checks to see if it has been addressed to talk. (A read statement is pending in the 9825A). If it hasn't the counter waits with that measurement until it has been addressed. It is application dependent as to which of these two modes to use.

5328A UNIVERSAL COUNTER

Option 011 makes the 5328A Universal Counter compatible with the HP-IB. At the simplest level the 5328A can output data to other devices such as the 5150A Thermal Printer or the 59303A Digital-to-Analog Converter. In more sophisticated systems a desktop computer or other system controller can remotely program the 5328A, trigger measurements, and read the results. With the addition of Option 041, the 5328A allows complete "hands-off" operation for the most involved systems applications. Option 041 adds full programmability of the input signal conditioning controls.

Setting Address Switches

To use the 5328A in an HP-IB system the first step is to set the rear panel address switches. The left-most switch sets the counter to ADDRESSABLE or TALK ONLY mode. ADDRESSABLE mode is used whenever a computer or other controller is used within the system. TALK ONLY mode is used when the counter will be controlled manually but the 5328A will output results to another device on the bus such as a printer or D-A converter.

The five right-hand switches, A5 through A1, set the talk and listen addresses of the 5328A when it is used in the ADDRESSABLE mode. The table 1-1 shows the possible address settings and the corresponding talk and listen addresses.

The examples listed in this note assume an address setting of 01010. This setting gives an address of 10 (ASCII J & *).

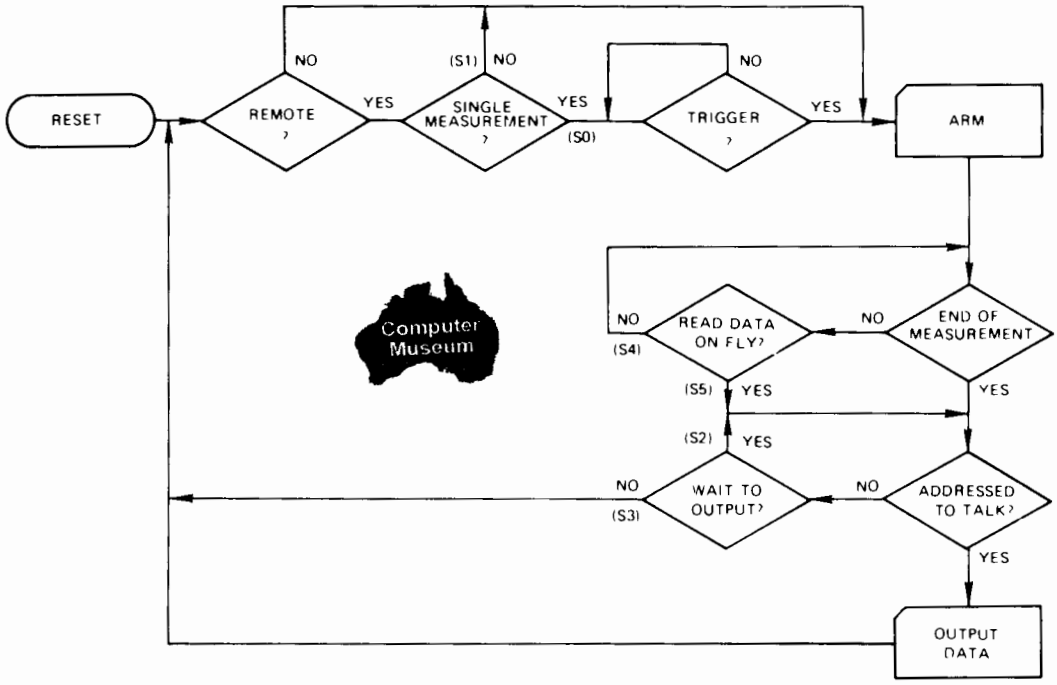
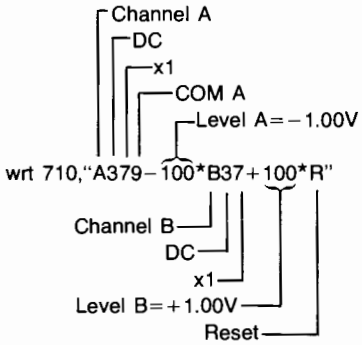


Figure 3-5. 5328A Measurement Cycle (Codes shown in parenthesis are from program code set.)

With option 041 it is possible to program the input signal conditioning controls of the A and B channels



The program codes are from the 19 groups of the Program Code Set, Table 2. Groups 12 through 18 apply only when Option 041 is installed in the counter. No more than one code from a group should be used in a program code string; use the codes in the same order that the groups are listed.

The code "P" gives a simple way to initialize the state of the counter program. "P" substitutes for:

"F0G0S0246A02468<+000*B02468+000R"

The Program Code Set shows these states in bold face. When other codes are included in a program code string, either "R" or "T" should be included at the end of the string. Both of these codes update the counters program storage cells. The code "T" also initiates a measurement; "R" does not.

CODE SIMPLIFICATIONS

In a string of codes, the prefix letter of a two-character code need not be repeated. The prefix letter can be used just once at the beginning of a sequence of codes:

"S1S3S4S6" — "S1346"
"A1A7A9A+123*" — A179+123*"

Triggering a Measurement

The computer must trigger each measurement when the 5328A is programmed for single measurement mode, "S0". Two trigger methods are available. The program code "T" offers the simplest way to trigger a measurement. However, the bus command, Group Execute Trigger, (GET) (trg 710 on 9825A) may also be used. The counter responds more quickly to GET; also, GET can trigger the counter simultaneously with other devices on the bus.

Using the program code "T" to trigger a measurement:

```
0: wrt 710,"T"
```

If the counter is programmed for multiple measurements, "S1", the counter will start each measurement without a trigger command. When the counter is also programmed to wait to output, "S2", it will start a new measurement as soon as the computer reads the previous one. In the continuous cycle mode, "S3", the counter does not wait to output, but starts a new measurement. This mode is useful for the user to visually monitor a series of readings.

Reading a Measurement

The examples below indicate how the 9825A desktop computer may read a measurement from the counter.
fmt; red 710, X (EXECUTE)
Note that the data output string from the 5328A may include a leading "O" when a counter measurement overflows. The example that follows shows how the computer may be programmed to accept an overflow reading.

```
0: dim A$[20]
1: conv 69,101;red 710,A$;conv
2: if A$[1,1]="O";prt "OVERFLOW";jmp -1
3: val(A$[2])→X
4: fxd 9;dsp X
```

Measurement Output Format

The 5328A transmits the following string of characters to output a measurement:

Position	1	2	3 thru 12	13	14	15	16	17
Character	O SP	+ –	9 digits and decimal point.	E	+ –	d	CR	LF

"O" in the first position indicates measurement overflow. Leading 0's in positions 3 to 12 are output as "SP" if they occur more than one position to the left of the decimal point and there is no overflow. The decimal point may appear at positions 4 to 12. The output string is always 17 characters long. Typical character output strings are:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
SP	+	5	0	3	2	1	7	•	6	9	8	E	+	3	CR	LF
SP	+	SP	SP	SP	5	4	3	2	•	1	0	E	–	3	CR	LF
O	+	0	5	3	1	8	•	5	4	2	0	E	+	3	CR	LF

The 5328A inserts a "0" in position 12 of the output string for all measurements that don't use the ninth digit of the display. This extra "0" fills the output string to a constant 17 characters.

Programming Examples

The following programs illustrate how the HP 9825A Desktop Computer can control the 5328A Counter. This program causes the counter to make a series of frequency measurements. The computer reads the measurements into memory and prints the results. The program assumes the counter address 10.

```
0: dim A[10]
1: rem 7
2: wrt 710,"PF4G6R"
3: for I=1 to 10
4: wrt 710,"T"
5: red 710,A[I]
6: prt A[I]
7: next I
8: end
```

Program Explanation

OPERATION	Line
Set HP-IB to Remote Enabled state	1
Program counter to frequency measurement, 1 Hz resolution	2
Trigger a measurement	4
Read the measurement	5
Print result	6

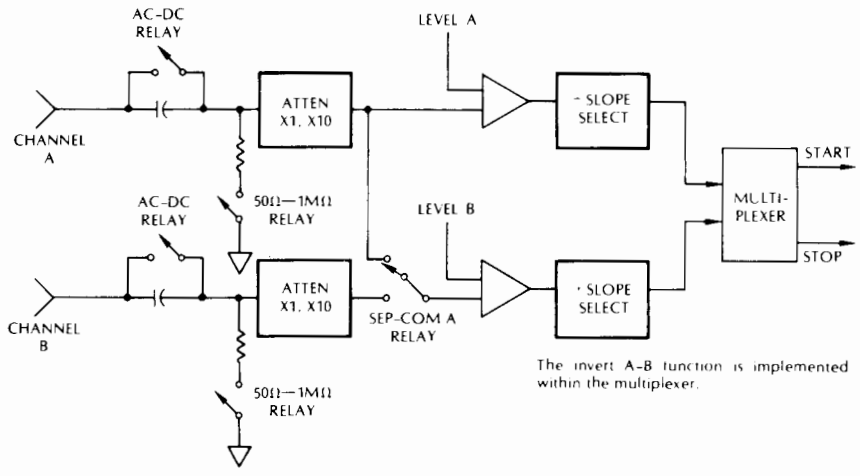


Figure 3-6. Option 041 Input Signal Conditioning

Table 3-2. Program Code Set

Codes shown in bold face are start-up conditions. These conditions are set by the code "P", Remote Program Initialize, or by the bus commands Device Clear or Selected Device Clear.

1. Initialization
   - P Remote Program Initialize
2. Function

FØ	**Stop**	F8	T.I. A→B
F1	Start A	F9	B/A
†F2	Start Clock	F:	T.I. Avg . A→
†F3	DVM/A	F;	Events C,T.I. A→B
F4	Freq. A	F<	Check
†F5	DVM/T.I. A→B	F=	C/A
F6	Period A	F>	Freq. C
F7	Per. Avg. A	F?	DVM

3. Time Base

Code	Freq Res	Multiplier	Time Res (Std)	Time Res (Opt. 040)
GØ	**1 MHz**	**1**	**100ns**	**10ns**
G1	100 kHz	10	1 μs	100ns
G2	10 kHz	10^2	10 μs	1 μs
G3	1 kHz	10^3	100 μs	10 μs
G4	100 Hz	10^4	1ms	100 μs
G5	10 Hz	10^5	10ms	1ms
G6	1 Hz	10^6	100ms	10ms
G7	0.1 Hz	10^7	1s	100ms

4. Single-Multiple Measurement
   - **SØ Single Measurement**
   - S1 Multiple Measurement
5. Measurement Cycle
   - **S2 Wait to output; Service Request at end of measurement**
   - S3 Continue cycle; no Service Request
6. Output Mode
   - **S4 Output at end of measurement**
   - S5 Output when addressed (on-the-fly)
7. Sample Rate
   - **S6 Maximum**
   - S7 Manual control (from front panel)
8. Arming
   - **S: Off**
   - S; On
9. Display Storage
   - **S< On (normal)**
   - S= Off
10. Decade Reset
    - **S> Normal**
    - S? Disabled (for cumulative measurements)
11. Display Blanking
    - **U Normal display**
    - Q Blank display (digits and decimal point)

†Functions not labeled on instrument front panel

Table 3-3. Program Code Set (Cont'd)

12. Channel A Signal Conditioning
    a. Impedance
       AØ 1 Megohm
       A1 50 Ohms
    b. Coupling
       A2 AC
       A3 DC
    c. Slope
       A4 +slope
       A5 -slope
    d. Attenuator
       A6 x10
       A7 x1

Code groups 12 to 18 apply only when Option 041 is installed.

13. Separate - Common
    A8 Separate
    A9 Common A
14. Check
    A< Normal Operation
    A? Check, Measures internal clock
15. Trigger Level A

    A{+/−}d_1 d_2 d_3 *

    (volts, tenths of volts, hundredths of volts)

    Permissible trigger level range: -2.50V to +2.50V.

The program sequence to set trigger level starts with the channel designation letter followed by a "+" or "-" sign. Next, three digits set the voltage level. An "*" terminates the sequence. The same sequence must be used even to set 0 volts.

Examples: "A+000*" 0 volts
"A-123*" -1.23 volts

16. Channel B Signal Conditioning
    a. Impedance
       BØ 1 Megohm
       B1 50 ohms
    b. Coupling
       B2 AC
       B3 DC
    c. Slope
       B4 +slope
       B5 -slope
    d. Attenuator
       B6 x10
       B7 x1
17. Trigger Level B
    B{+/−}d_1 d_2 d_3 *

    See Group 15, Trigger Level A, for details.
18. Channel Invert
    B8 Normal
    B9 Invert A and B inputs
19. Reset; Trigger
    (Also see Bus Command GET)
    R Reset, no trigger
    T Reset and trigger

Bus Commands

The 5328A Universal Counter obeys the following Bus Commands (the HP-IB User's Guides describe the function of these commands):

Universal Commands

llo7	Local Lockout Disables all programmable controls including reset. Go to Local (GTL) may be used to return to manual control.
clr 710	Device Clear Resets the programmed state of the counter to the codes shown in bold face in the program code set. Has the same effect as the program code "P".
rds(710)→X	Serial Poll Sets the counter to the serial poll mode. When addressed to talk during the serial poll mode, the 5328A produces a status byte to indicate its condition. If the counter has completed a measurement and is requesting service, the status byte contains a "1" in bit 7 (decimal value 64). If the counter has not requested service, the status byte will be "0" in all bits. When addressed to talk in the serial poll mode, the counter will immediately stop requesting service.

Addressed Commands

lcl 710	Go to Local Returns the 5328A to local (manual) control from remote control.
clr 710	Selected Device Clear Responds as with Device Clear or program code "P".
trg 710	Group Execute Trigger Starts a measurement. This command provides the quickest method to start a measurement cycle.

5340A FREQUENCY COUNTER

The 5340A Frequency Counter can be programmed on the HP-IB by setting it to remote using the ASCII letter O sent as a character string. To set the counter to remote, send the following command (device address is assumed to be 16, bit 5 to a 1 all others (1 - 4) to 0): (Refer to table 3-4).

```
0: wrt 716,"O"
```

The resolution Hz switch can be set to any position by sending the ASCII character corresponding to its switch position starting with 1 Hz as 0. For example the ASCII character 2 would set 100 Hz resolution.

The sample rate switch can be set to hold by sending the ASCII character K followed by an ASCII I or if it is desired to take the unit out of hold under software control, the ASCII character J can be sent.

The 5340A has two output modes: ONLY IF addressed and WAIT until addressed. Normally the ONLY IF addressed mode should be used.

The range switch can be programmed by sending the ASCII characters S, U, T or P.

When the 5340A is read a normal reading would appear as: D␣␣XXXXXXXX E + X
(Refer to table 3-5).

It would be advisable to read the 5340A into a string variable. However, red 716, X command can be used to get the reading into standard form for use with variables.

If an overrange occurs, the second character will be (O) but the rest of the characters will be interpreted as normal data and an incorrect reading would be obtained because the data field would be filled with the truncated result.

Example program:

```
0: dim A$[20]
1: wrt 716,"O0JS"
2: conv 69,101;red 716,A$;conv
3: if A$[2,2]="O";prt "OVERFLOW";jmp -1
4: val(A$[4])→X
5: dsp X
```

This program will set the counter to remote, select 1 Hz resolution use internal triggering and the 10 Hz-250MHz (hi Z) range. The reading will be read into string variable A$ and checked for overflow. The conv statement converts E to e (cap to lower case) so that the scientific notation conversion will work properly. If checking for overflow is not required statements 2 to 4 can be replaced with simply red 716, X.

The 5340A has a group of storage cells that are used to store program information. They are used ONLY when a controller has the 5340A operating under remote control. The ASCII characters that can be stored in each cell and their relationship to the 5340's operations are shown in the following table.

Table 3-4. 5340A Program Codes

Resolution	Hz	ASCII	Binary							Octal
			B_7	B_6	B_5	B_4	B_3	B_2	B_1	
1	10^0	Ø	0	1	1	0	0	0	0	060
10	10^1	1	0	1	1	0	0	0	1	061
100	10^2	2	0	1	1	0	0	1	0	062
1K	10^3	3	0	1	1	0	0	1	1	063
10K	10^4	4	0	1	1	0	1	0	0	064
100K	10^5	5	0	1	1	0	1	0	1	065
1M	10^6	6	0	1	1	0	1	1	0	066
Ranges										
10 Hz - 250 MHz (hi Z)		S	1	0	1	0	0	1	1	123
Check		U	1	0	1	0	1	0	1	125
250 MHz - 18 GHz (50Ω)		T	1	0	1	0	1	0	0	124
10 Hz - 18 GHz (50Ω)		P	1	0	1	0	0	0	0	120
Octave Ranges (use with T&P only)										
Auto		@	1	0	0	0	0	0	0	100
≥8 GHz		A	1	0	0	0	0	0	1	101
4 GHz - 8 GHz		B	1	0	0	0	0	1	0	102
2 GHz - 4 GHz		C	1	0	0	0	0	1	1	103
1 GHz - 2 GHz		D	1	0	0	0	1	0	0	104
500 MHz - 1 GHz		E	1	0	0	0	1	0	1	105
250 MHz - 500 MHz		F	1	0	0	0	1	1	0	106
10 Hz - 250 MHz		G	1	0	0	0	1	1	1	107
Sample Rate										
Internal Sample Rate		J	1	0	0	1	0	1	0	112
Hold		K	1	0	0	1	0	1	1	113
SAMPLE TRIGGER (measure)		I	1	0	0	1	0	0	1	111
RESET		H	1	0	0	1	0	0	0	110
OUTPUT MODES										
ONLY IF addressed		L	1	0	0	1	1	0	0	114
WAIT until addressed		M	1	0	0	1	1	0	1	115
Local-Remote										
Local (front panel) control		N	1	0	0	1	1	1	0	116
Remote (program storage cell) control		O	1	0	0	1	1	1	1	117
RESET PUSHBUTTON/POWER UP conditions are Ø, P, @, J, L. N										

Table 3-5. 5340A Output Codes

ORDER OUTPUTTED	CHARACTER	DESCRIPTION
1	D/L	D - measurement made direct or L - measurement made using phase locked loops
2	O/SP	O - 5340A's display has overflowed or SP - Space (0 100 000 binary, 040 octal)
3	SP	Space
4 thru 11	Ø - 9	Digits Ø thru 9 (blank display digits outputted as Ø) most significant digit first
12	E	Power of 10 exponent to follow
13	+	Exponent is positive (0 101 011 binary, 053 octal)
14	Ø - 6	One digit exponent
15	CR	Carriage return (0 001 101 binary, 015 octal)
16	LF	Line feed (used as a word terminator) (0 001 010 binary, 012 octal)

5345A ELECTRONIC COUNTER

The 5345A is a device which is both a talker and a listener on the bus. The CHECK/COM A/SEP switch as well as Function and Gate Time can be programmed when the 5345A is operated as a listener on the HP-IB.

It can function as a talker by sending its reading back to the computer. It has two talk addresses: one for sending the reading back to the computer in the normal ASCII format and the other talk address (the next higher odd number above its address setting) for what is called the computer dump mode which outputs the reading in an unprocessed format. Refer to the 5345A Operating and Service manual for additional information on the computer dump mode. It should be noted that the address switches on the 5345LKA are A5 to A2. A1 is not available because of the need for an even number to allow the computer dump address to be odd. Device address 722 is used for this example.

The counter should be first programmed to its power up condition by sending I2E8 as a program code. By sending I2E8 as a program code, the counter goes into remote (E8) and selects specific conditions as shown in table 3-5. I2 sets the counter to measure frequency and sets a one-second gate time and also sets D0,E7,E0,E2,E3,E1,E4 and E5. If this setup is not what is desired, send the command I2 followed by the desired program codes.

wrt 722, "I2E8F1" would set the power up conditions and then set the counter to measure period.

```
0: wrt 722,"I2E8"
```

The counter has a buffer between the actual counter registers and the HP-IB. This counter has zeros in it during power up and the previous reading in it during operation. Care should be taken when reading the counter that the reading the computer gets from the counter is the one desired and not the previous reading. Example:

```
0: wrt 722,"I2E8"      Program power up condition
1: red 722,Z           Dummy reading to dump buffer
2: red 722,V           Actual reading
```

Table 3-6. 5345A Frequency Counter Program Codes

1. Function — **ASCII**

a.	Plug-In	F2
b.	Frequency A	**F0**
c.	Period	F1
d.	Time Interval A to B	F3
e.	Ratio B/A	F5
f.	Start	F4
g.	Stop	F6

2. Gate Time

a.	10000 sec	G4
b.	1000 sec	G3
c.	100 sec	G2
d.	10 sec	G1
e.	1 sec	**G0**
f.	100 ms	G?
g.	10 ms	G>
h.	1 ms	G=
i.	100 μs	G< or G<*
j.	10 μs	G;
k.	1 μs	G:
l.	100 nsec	G9
m.	Min	G5

3A. Display Position

(Digits from E in Data String) (Digit Position Defined from Right to Left, Decimal Point on Right Side of Digit)

a.	0 Digits	D:
b.	1 Digit	D:
c.	2 Digits	D9
d.	3 Digits	D8
e.	4 Digits	D?
f.	5 Digits	D>
g.	6 Digits	D=
h.	7 Digits	D< or D<*
i.	8 Digits	D3
j.	9 Digits	D2
k.	10 Digits	D1
l.	Auto Position +	**D0**
	Auto Suffix	
	Multiplier	

3B. Display Multiplier Suffix

FREQ.	PERIOD TIME INTERVAL	START/ RATIO	ASCII
GHz	nsec	G	C7
MHz	μsec	M	C6
kHz	msec	k	C5
Hz	sec		C4
mHz	ksec		C3

4. Reset

a.	Machine reset	I1
b.	Remote Program Initialize	I2

5. Input Amplifier Control

a.	COM A or Separate	**E7**
b.	Check	E?

6. Local-Remote

Selects remote upon addressing provided the bus line REN is assertive.

7. Output Mode

a.	Output only if addressed to Talk; bypass if not addressed to Talk	**E2**
b.	Hold current measurement until addressed to Talk	E:

NOTE

The output routine will be bypassed in the wait mode (ASCE:) if the bus is in the DATA MODE with no listeners. This is the result of a 5345A feature which prevents hang-up of the 5345A in the event the HP-IB cable is disconnected.

8. Remote Gating

a.	Enable Rear Panel External Gate	E;
b.	Disable Rear Panel External Gate	**E3**

9. Sample Rate

(Wait Time Between Measurements)

a.	Not Hold	**E1**
	1. Min Time (1-5 msec)	E< or E<*
	2. ≈50 msec time (Required for Start Function)	**E4**
b.	Hold	E9
	1. Take a measurement	J1

10. Accum Mode Start/Stop

A+B	E=
A-B	**E5**

11. Slope

Slope B +	**E0****
Slope B -	E8**
Slope A +	E6
Slope A -	E>

12. Trigger Levels

Level A	ADDD
Level B	BDDD

D=ASCII Digit 0-9

NOTE

On power up, these levels are random.

$$\text{Trigger Level in Voltage} = \frac{DDD}{250} - 2.000 \text{ for } 000 < DDD < 999$$

AND

A Chan A:00 = +2.000
B Chan B:00 = +2.000

NOTE

These codes are useful when calibrating the DAC.

*For 9820A/9821A Calculators
**Codes have different function for Option 011

RESET PUSHBUTTON/POWER UP/I2 PROGRAM conditions are **F0, G0, D0, E7, E0, E2, E3, E1, E4, E5**

Chapter 4
PROGRAMMING STIMULUS INSTRUMENTS

This section contains information on three widely used stimulus instruments: the 59501A D/A Power Supply Programmer, the 59308A Timing Generator, and the 3330B Frequency Synthesizer.

59501A D/A POWER SUPPLY PROGRAMMER

This power supply has the ability to output several different types of dc voltages via the HP-IB. It can output in its bipolar mode ±10 volts with 20 millivolt resolution or ±1volt with 20 millivolt resolution. In its unipolar mode 0 to 10 or 0 to 1 volt is available with 10 Mv and Mv resolution respectively. Unipolar mode or bipolar mode is selected on the back of the unit and is not programmable. The 1 volt or 10 volt range is programmable via the bus. To select the 1 volt range, 1 is sent as the first of four characters. To select 10 volts 2 is sent as the first of four characters. If the unit is set up in the bipolar mode, the unit is programmed as follows:

```
0: wrt 707,"2000"
1: wrt 707,"2500"          All on 10 volt range
2: wrt 707,"2999"
```

Assume device number 07 is used (be careful selecting address switch positions, they are reversed and inverted from most other instruments).

To set up a program to convert a variable representing voltage to a 59501A command the following example can be used.

```
0: ent "DESIRED DC VOLTAGE",V
1: 50V+2500→N
2: if N>2999;2999→N
3: fmt 1,f4.0;wrt 707.1,N
4: gto 0
5: end
```

If the ±1 volt range is desired, the expression in line 1 would be changed to 500V+1500 N and the 2999 in line 3 changed to 1999.

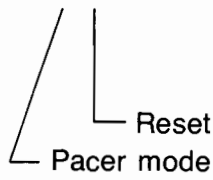
The 59501A can also be used to output a sinewave or other waveform generated by an equation in the computer. For example, the value of sin varies between −1 and 1. An example of a sinewave output:

```
0: for I=0 to 359
1: 2499+499sin(I)→N
2: fmt 1,f4.0;wrt 707.1,N
3: next I
4: gto 0
```

HINT: Get in the habit of using referenced format statements. It will avoid problems with complex programs.

59308A TIMING GENERATOR

The normal use of the timing generator with a bus system is to allow the computer to be interrupted when a preset interval has elapsed. This is called the pacer mode. The Timing generator needs to see a 3 digit number with an exponent capital E followed by a single digit number, which would be 6 for microseconds. For example wrt 708, "015E6PR" would program a 15 second interval between interrupts.



The statement wrt 708, "615E3PSR" would program the timer to interrupt (pull SRQ) every 615 milliseconds and send the proper commands to put the unit into the pacer mode. The following example program will program the timing Generator to a time T selected by the operator and interrupt a running program which is displaying the contents of a incremented variable.

```
0: "TIMING GEN":
1: dim A$[10]
2: oni 7,"INT"
3: ent "TIME INTERVAL IN SEC",T
4: flt 2;str(1e4T)→A$
5: A$[2,2]&A$[4,5]&"E"&A$[9,9]&"PSR"→A$
6: wrt 708,A$
7: eir 7
8: fxd 0
9: 1+I→I
10: dsp I
11: wait 100
12: gto -3
13: end
14: "INT":
15: rds(708)→S
16: red 708,X
17: beep
18: dsp XT,"SECONDS ELAPSED"
19: wait 1000
20: eir 7;iret
```

The timing generator also has an internal 4 digit counter which may be interrogated to find out how many intervals have elapsed. This is done by red 708,X. The variable X will contain the number of intervals that have elapsed since the generator was initialized.

3330B FREQUENCY SYNTHESIZER

The 3330B can be set to frequencies in the range of .1 Hz to 13.000999.9 MHz. Amplitudes can be set from −86.55 dbm to +13.44 dbm into a 50 ohm load. The synthesizer needs program codes such as **L** for frequency, **=** for Hz, **N** for amplitude in dbm, **;** for +dbm. The device address of the 3330B is set inside the instrument to 04.

For example to set +13 dbm and 125 Hz would be:

```
0: wrt 704,"L125=N13;"
```

to set −30 dbm at 10 MHz would be

```
0: wrt 704,"L10000000=N30<"
```

Table 4-1 shows programming codes for the 3330B.

The following subroutine allows values of frequency and values of voltage into a 50 ohm load (must be installed for proper amplitude) to be programmed from operator inputs.

```
0: ent "FREQUENCY (HZ)?",F
1: if F<.1 or F>13000999.9;jmp -1
2: ent "AMPLITUDE (VOLTS)?",V
3: 20log(4.472abs(V))→A
4: if A>13.44 or A<-86.55;jmp -2
5: fmt "L",f.1,"=";wrt 704,F
6: if A>0;fmt "N",f.2,";";wrt 704,A;jmp 2
7: fmt "N",f.2,"<";wrt 704,A
8: end
```

The 3330B "wakes UP" in the remote mode if it is attached to the bus and the REN line is set as it usually is in the 9825A. The 3330B can be set to local only by the lcl 7 command. It does not respond to the selected device go to local command lcl 704.

Chapter 5
PROGRAMMING DISPLAY DEVICES

This section contains information on two display devices: the 59304A Numeric Display and the 9871A Printer Plotter.

59304A NUMERIC DISPLAY

The numeric display will accept the following characters:

Space, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, E, −,.

To output a numeric field such as 1256 the following command can be used:

```
0: wrt 706,"1256"
```

If it is desired to center the numbers on the display

`0: wrt 706,"1256␣␣␣"` would be used (␣indicates space).

A format statement should be used to output variables. For example to output the variable X equal to 1.28760

```
0: 1.2876→X;fmt 1,f10.4;wrt 706.1,X
```

To output in scientific notation fmt f10.4 could be changed to e10.2
The value of the numbers in the format is data dependent and therefore up to the user.

If it is desired to output more than one number at a time to the display this can be done provided no more than 16 total characters are used.

```
0: 468→X
1: 32.6→Y
2: fmt 1,f3.0,x,f4.1
3: wrt 706.1,X,Y
4: end
```

Note: One characteristic of the 59304A is that it can only display *one* decimal point per reading.

9871A PRINTER PLOTTER

The 9871A can be specified to interface to the 9825A with either the 98034 HP-IB card or 98032A 16 bit I/O card. This discussion is limited to the 9871A Option 001 interfaced via the HP-IB. The address switches for the HP-IB interface are located inside the 9871A just in front of the HP-IB connector. To set a particular address, orient the address switch board so that the lettering on the board is upright. Read the address switches left to right and set the switches such that "OFF" means "1" and "ON" means "0". For example to set address 15 1, 2, 3 and 4 would be off and 5 on. This would give $2^0+2^1+2^2+2^3$ which equals 15.

To list a program on the 9871, execute list #715.

To write data to the 9871A, use the 9871A as though it is any HP-IB device.

For example to output 1 to 10 squared:

```
0: for I=1 to 10
1: II→X
2: wrt 701,X
3: next I
4: end
```

To output the 9871A's character set, the following one line program can be executed.

```
0: fmt b;for I=0 to 127;wrt 701,I;next I
```

When using the plotting examples for the 9871A in the 9825A General Utility pac, change statements referencing device 6 to 715. For example to plot the sinewave on file 42 of the General Utility Pac change 6 →r0 in line 0 to 715 →r0 and wrt 6 in line 20 to wrt 715.

The following is a verification program for the 9871A which will plot a sin (X)/X curve and print the character set.

```
0: "PTR Op Ve Ck-9871A Impact Printer Oper. Verif. Check":
1: prt "****************";spc ;prt "  9871A PRINTER","   Oper. Verif."
2: prt "      Check","      101476";spc 2
3: time 5000
4: on err "Time out"
5: dev "ptr",715;cli 7;clr 7
6: "SRQ TEST":rds("ptr")→A
7: gto +3;if A#16;prt "PTR output","incorrect Status";gto +1
8: fmt "Byte-",f3.0,"-."
9: wrt 16,A;prt "Insure cover","is on then","repeat TEST.";spc 2;end
10: "FUNCTIONAL TEST":fmt 6b;rad
11: wrt "ptr",27,122
12: wait 10000
13: wrt "ptr",27,79,int(6.6*120/64),int(6.6*120),int(5.5*96/64),int(5.5*96)
14: for I=-4π to 4π by .1π
15: I/4π*6.5*120→X
16: sin(I)/I*528→Y
17: fmt 7b,z
18: wrt "ptr",27,65,int(X/64),int(X),int(Y/64),int(Y),42
19: next I
20: wrt "ptr",10,10,10,10,10,10
21: wrt "ptr",27,122
22: prt "Check the print-","out against the","sample found in"
23: prt "Section 2 of the","System Manual.";spc 2
24: "END":wait 10000;cli 7;clr 7;end
25: "Time out":prt "PTR did not","respond to Bus","commands within"
26: prt "5 seconds.","Check cables","and run test","again.";spc 2;end
*6890
```

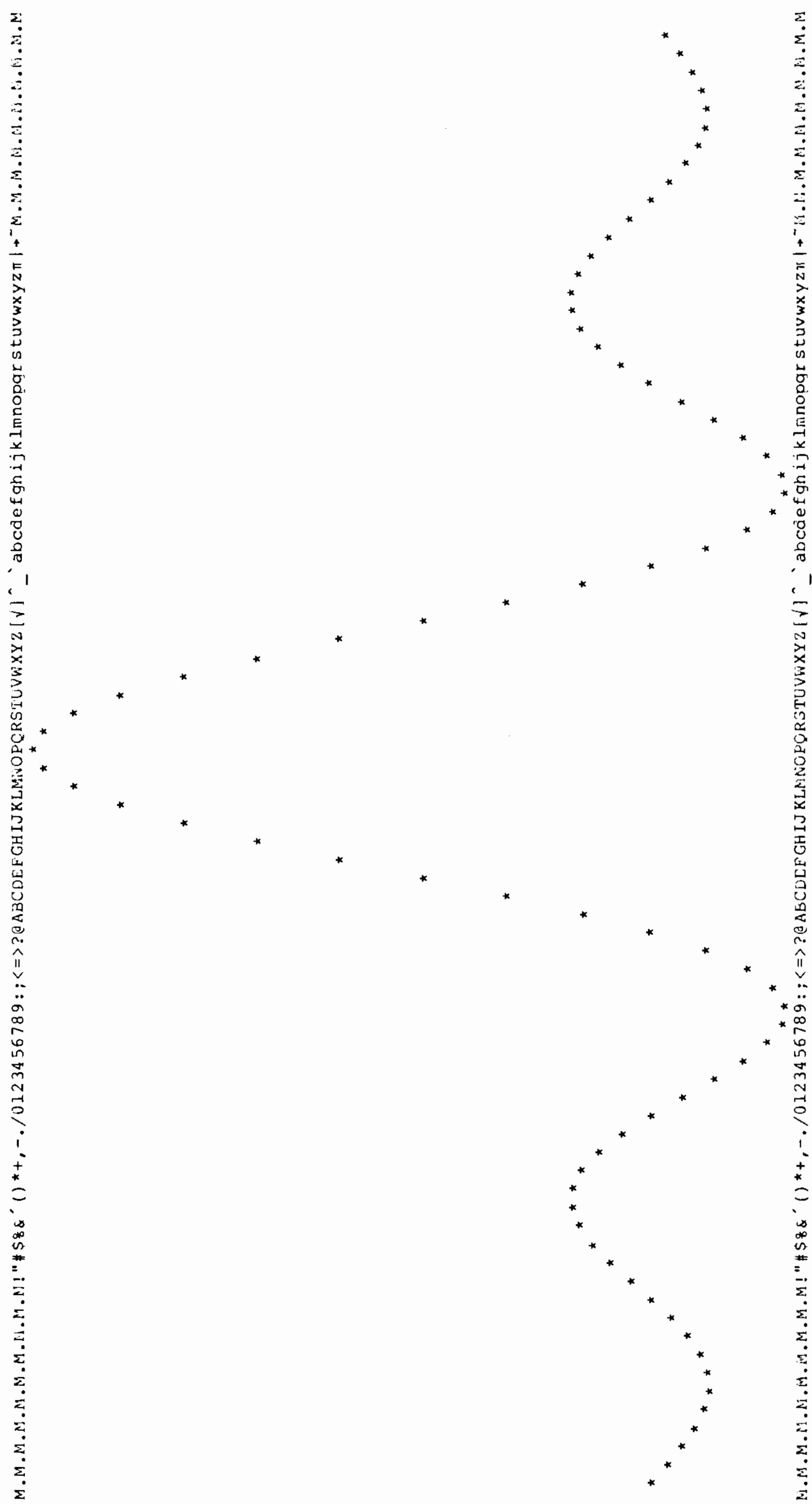


Figure 5-1. Plot of sin (X)/X

Table 5-1. 9871A Printer Programming Summary

HP-IB Messages

CATEGORY and MESSAGE	DESCRIPTION	PRINTER RESPONSE
Device Communication		
DATA	Transfer device dependent information between a talker and one or more listeners. May be device programming information or readings	As a listener, the printer accepts character and function codes, described in Chapter 2, from the controller
Device Control		None
Interrupt/Service		
REQUIRE SERVICE	Indicates a device's need for interaction with the controller	A request service signal is sent to the controller when the printer's cover is off.
Device Status		
STATUS BYTE	Transfer a Byte (8 Bits) of status information to a listener. One Bit indicates whether or not the device is currently sending the require service message. The other 7 Bits (optional) indicate device dependent status	As a talker, the printer outputs a status byte to the controller (during a serial poll)
STATUS BIT	Transfer a single Bit of device dependent status which may be logically (and/or) combined with other Status Bit messages to the Controller	During a parallel poll, a status bit is sent to the controller on a selected data line
System Control		
PASS CONTROL	Passes bus controller responsibilities from the current controller to a device which can assume the bus supervisory role	None
ABORT	Causes control to unconditionally pass back to the system controller, independent of the device currently in control	An abort message will clear the printer's buffer. All the printer's programmable feature settings remain.

9871A Character Set

Decimal Code	Spoke Number	Standard Characters
33	48	!
34	61	"
35	23	#
36	24	$
37	5	%
38	9	&
39	2	'
39 (SO)	89	'
40	38	(
41	36	)
42	26	*
43	25	+
44	6	,
45	27	-
46	33	.
47	31	/
48	18	0
49	17	1
50	19	2
51	16	3
52	20	4
53	15	5
54	21	6
55	14	7
56	22	8
57	13	9
58	52	:
59	59	;
60	10	<
61	29	=
62	12	>
63	54	?
64	7	@
65	47	A
66	58	B
67	39	C
68	53	D
69	45	E
70	57	F
71	34	G
72	41	H
73	50	I
74	66	J
75	30	K
76	55	L
77	37	M
78	49	N
79	51	O
80	56	P
81	65	Q
82	43	R
83	44	S
84	46	T
85	60	U
86	62	V
87	32	W
88	28	X
89	35	Y
90	63	Z
91	42	[
92	3	\
93	40	]
94	1	^
94 (SO)	8	↑
95	11	_
96	95	`
97	85	a
98	93	b
99	75	c
100	86	d
101	82	e
102	74	f
103	73	g
104	81	h
105	79	i
106	91	j
107	72	k
108	87	l
109	90	m
110	78	n
111	77	o
112	92	p
113	69	q
114	83	r
115	84	s
116	80	t
117	76	u
118	71	v
119	88	w
120	70	x
121	67	y
122	68	z
123	4	π
124	64	|
125	94	→
126	96	∿

Here are the unique characters found on the ASCII character disk

Decimal Code	Spoke Number	ASCII Character
92	3	\
123	4	{
125	94	}

Here are the unique characters found on the European character disk

Decimal Code	Spoke Number	European Character
35	23	£
39 (SO)	89	Ç
92	3	¿
94 (SO)	8	°
123	4	¨ (U.C.)
125	94	¨ (L.C.)

The character spokes are numbered clockwise, 1 to 96, beginning with the circumflex (^) character. Hold the character disk with the characters facing you and the locating tab up. The circumflex character (spoke 1) will be on top.

Figure 5-2. 9871A Character Set

Table 5-2. Complete List of 9871A Function Codes

COMMAND	COMMAND CODE		
	ASCII CHARACTER	DECIMAL CODE	DECIMAL PARAMETER
GENERAL			
• Bell	BELL	7	
• Backspace	BS	8	
• Linefeed	LF	10	
• Carrier Return	CR	13	
• Shift Out	SO	14	
• Shift In	SI	15	
• View Delay	ESC, D	27, 68	INT(N/64),INT N
• Reverse Line Feed	ESC, LF	27, 10	
• Character Replacement	ESC, C	27, 67	"CHAR", N, "LIST"
• Reset	ESC, E	27, 69	
• Self Test	ESC, R	27, 122	
HORIZONTAL TABULATION			
• Set Horizontal Tab	ESC, 1	27, 49	
• Clear Horizontal Tab	ESC, 2	27, 50	
• Clear All Horizontal Tabs	ESC, 3	27, 51	
• Horizontal Tab Right	HTAB	9	
• Horizontal Tab Left	ESC, 4	27, 52	
VERTICAL TABULATION			
• Set Vertical Tab	ESC 5	27, 53	
• Clear Vertical Tab	ESC, 6	27, 54	
• Clear All Vertical Tabs	ESC, 7	27, 55	
• Vertical Tab Up	ESC, 8	27, 56	
• Vertical Tab Down	VTAB	11	
FORM AND MARGIN CONTROL			
• Set Top of Form	ESC, T	27, 84	
• Form Length	ESC, F	27, 70	INT(N/64), INT N
• Text Length	ESC, L	27, 76	INT(N/64), INT N
• Form Feed	FF	12	
• Set Left Margin	ESC, M	27, 77	
• Text Width	ESC, W	27, 87	INT(N/64), INT N
SPACING CONTROL			
• Horizontal Spacing	ESC, H	27, 72	INT(N/64), INT N
• Vertical Spacing	ESC, V	27, 86	INT(N/64), INT N
• Variable Spacing	ESC, S	27, 83	
PLOTTING CONTROL			
• Absolute Plot	ESC, A	27, 65	INT(X/64), INT X, INT(Y/64), INT Y
• Relative Plot	ESC, R	27, 82	INT(X/64), INT X, INT(Y/64), INT Y
• Character Fill Setup	ESC, .	27, 46	P1, INT(P2/64), INT P2, P3
• Absolute Plot With Fill	ESC, a	27, 97	INT(X/64), INT X, INT(Y/64), INT Y
• Relative Plot With Fill	ESC, r	27, 114	INT(X/64), INT X, INT(Y/64), INT Y
• Plot Origin	ESC, O	27, 79	INT(X/64), INT X, INT(Y/64), INT Y

Chapter 6
PROGRAMMING COMPUTATION AND CONTROL DEVICES

Two special configurations are considered in this section. One is a 9825A communicating with another 9825A. The other is a 9825A communicating with a 9830A/B. Both use the HP-IB for the interconnect.

9825A COMMUNICATING WITH 9825A

To connect two 9825A's together, one of the desktop computers must have its 98034A I/O card changed so that it has a different address than 21 and it is not the system controller. To do this take the interface card apart and locate the address switches and change switches 1 and 6 to the opposite position. This makes the device address 20 rather than 21. Connect the two 98034A together via the HP-IB connector.

The following example sends the numbers 1 to 10 squared from the slave 9825A to the system controller 9825A.

Slave

```
0: for I=1 to 10
1: II→X
2: wrt 731,X
3: next I
```

Note in line 2: wrt 731,X uses an address "31" which is beyond the range of allowable TALK/listen address codes (see Table 1-1). The "31" is reserved for this special case. Technically it does not set ATN true on the bus. Setting ATN true can only be done by the system controller.

Master

```
0: red 720,X
1: prt X
2: gto 0
```

Strings (ASCII characters) can be sent from one computer to the other.

Slave

```
0: dim A$[80]
1: ent A$
2: wrt 731,A$
3: jmp -2
```

Master

```
0: dim B$[80]
1: red 720,B$
2: dsp B$
3: gto 1
```

If it is desired to send information from the master to the slave, just reverse the red and wrt statements in the two programs.

To use the two computers as a "telecommunications link" the following two programs will allow the two computers to pass information. The system that presses CONTINUE first after data is entered overrides the other. Control is passed from one computer to the other.

```
0: "Computers communicating (SYS.CTRL. dev.21)":
1: dim A$[32],B$[32]
2: oni 7,"INPUT",2
3: eir 7
4: ent "?",A$
5: "OUTPUT":if bit(6,rds(7));pct 720
6: rqs 7,64;wait 10;wrt 731,A$;gto 4
7: "INPUT":rds(720)→S;red 720,B$;prt B$;spc 2;gto 2
8: end
```

```
0: "Computers communicating (dev.20)":
1: dim A$[32],B$[32]
2: oni 7,"INPUT",2
3: eir 7
4: ent "?",A$
5: "OUTPUT":if bit(6,rds(7));pct 721
6: rqs 7,64;wait 10;wrt 731,A$;gto 4
7: "INPUT":rds(721)→S;red 721,B$;prt B$;spc 2;gto 2
8: end
```

9825A COMMUNICATING WITH 9830A/B

The 9830A/B and 9825A controllers can be connected together on the HP-IB if the 9825A is set so that it is not the system controller (there can be only one system controller at a time). The 9830A/B cannot be changed to not be the system controller so the 9825A is changed to be the slave unit even though it is the more powerful of the two units.

To make the 9825A not the system controller take the 98034A interface card apart and move address switch 1 to on and 6 to off. This makes the 9825A not the system controller and changes its address from 21 (ASCII U/5) to 20 (ASCII T/4).

Set up the two computers with the 9830A/B containing an extended I/O ROM and the 9825A containing a String-AP ROM and a General/Extended I/O ROM. Connect the 98034A to the 59405A HP-IB interface card.

The following program will send all the numbers from 1 to 10 squared (1, 4, 9, 16, etc.) from the 9830A/B to the 9825A and print the result on the strip printer on the 9825A. Push STOP EXECUTE, RUN EXECUTE on the 9830A/B before running the 9825A program.

9830A/B Program:

```
10 CMD "?U4"
20 FOR I=1 TO 10
30 X=I*I
40 OUTPUT (13,*)X
50 NEXT I
60 END
```

9825A program:

```
0: dim A[10]
1: for I=1 to 10
2: red 731,A[I]
3: next I
4: spc
5: for J=1 to 10
6: prt A[J]
7: next J
```

The following program will transfer the numbers from 1 to 10 squared from the 9825A to the 9830A/B:

9825A Program:

```
0: for I=1 to 10
1: II→X
2: wrt 731,X
3: next I
4: end
```

9830A/B Program:

```
10 DIM A[10]
20 CMD "?T5"
30 FOR I=1 TO 10
40 ENTER (13,*)A[I]
50 NEXT I
60 FOR J=1 TO 10
70 PRINT A[J]
80 NEXT J
90 END
```

Chapter 7

TRANSMITTING HP-IB INFORMATION OVER LONG DISTANCES

Sometimes it is desirable to measure and control or pass measurements beyond the cable length restrictions imposed by IEEE-488. These restrictions, 20 meters or 2 meters times the number of system devices, are discussed in more detail in Chapter 1. This chapter deals with using the 59403A Common Carrier Interface to communicate over longer distances.

59403A COMMON CARRIER INTERFACE

The CCI's are designed to work in pairs to allow instruments which are not located in close proximity to the controller to be accessed by the controller. They can be connected to phone lines via modems (synchronous or asynchronous) or can be connected together via a 4 wire twisted cable up to 1000 meters (about 3000 feet) apart. The latter is referred to as the dedicated mode. When connecting the dedicated lines, the wires at each end are connected to opposite pins. Pin 1 on one end is wired to pin 4 on the opposite end and pin 2 on one end is wired to pin 3 on the opposite end.

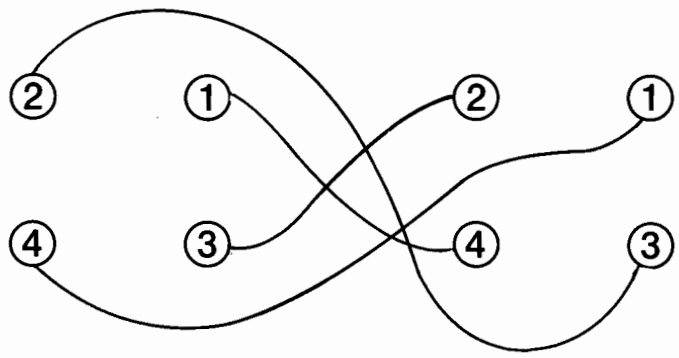


Figure 7-1. 59403A CCI Dedicated Line

When the CCI's are received, they are both set to address 17 (ASCII 1). One of the units should be designated as the "local" CCI, located at the computer end of the system and should be left at address 17 (ASCII 1). The other CCI should be designated as "remote" and should be set to address 18 (ASCII 2). The address switch is located inside the unit and is backwards and upside down from most other instruments. Switches 6 and 7 should be set to "ON" on both local and remote CCI's, and 1 off; 2, 3 on; 4 off and 5 on for address 18 (remote CCI). Local CCI should be set with 1 off; 2, 3 and 4 on; 5 off, 6 and 7 on.

The INTERFACE switches on the front panel should be set to DED, baud rate buttons all out and PARITY NONE for both units. Turn the power OFF and then ON after setting these switches on both units.

The CCI's should be programmed using command statements to get the CCI's into the handshake mode and put them on line. Once the CCI's are put on line and in handshake mode they become transparent to further bus traffic other than IFC. The following program will put the CCI's into the handshake mode and on line. The rest of the program is normal 3455A DVM programming to show the transparency of the CCI's.

```
0: "CCI DEMO":
1: cmd 7,"?U1","L";wait 500
2: cmd 7,"2";wait 500
3: cmd 7,"12","H";wait 500
4: fmt ;wrt 722,"F1R7T2T3"
5: trg 722;fxd 7;red 722,X;dsp X
6: gto -1
```

Computer talk, local CCI listen
Set on line then wait 1/2 second

Set remote CCI on line
Then wait 1/2 second

Put both CCI's into handshake mode simultaneously 1/2 second to allow settling

Set range and function on DVM

Trigger measurement
Read DVM and Display result

This same program may be used with many modem acoustic couplers such as the Anderson-Jacobson AD342. The CCI's should be set to 300 baud and ASYNC. Cycle both power switches on and off. A cable to connect the acoustic coupler to the CCI is usually available from the manufacturer. For example, with the coupler mentioned above, you can use the Anderson-Jacobson model 841 EIA cable. Put one acoustic coupler to originate and the other to answer. Use full duplex. Complete the telephone call and connect the phones to the coupler and program the same way as in the dedicated mode.

Chapter 8
WORKSHOP PROBLEMS

This section will give you practice solving problems using the 9825A.

9825A HP-IB ADDRESSING

TALK/LISTEN IS SET BY wrt/red

"wrt"; DATA TO A DEVICE
"red"; DATA FROM A DEVICE

Table 8-1. Address Codes

ASCII ADDRESS	5 BIT BINARY EQUIVALENT	DECIMAL EQUIVALENT OF 5 BIT VALUE
0 P	10000	16
1 Q	10001	17
2 R	10010	18
3 S	10011	19
4 T	10100	20
5 U	10101	21
6 V	10110	22
7 W	10111	23
8 X	11000	24
9 Y	11001	25

EXAMPLE:
3490A Talk
Address is V

3490A Listen
Address is 6

Using the 9825A with GPIO and the HP-IB interface card (factory set select code of 7) the 3490A would "listen" to the 9825A (actually to the 98034A interface card) if a wrt 722 were executed by the computer. If a red 722 were executed by the computer, the 3490A would be a talker and the 9825A would be a listener.

1 An HP-IB instrument has a talk address of T and a listen address of 4 which is represented by the 5 bit binary pattern of 10100.
Using the 9825A with red or wrt statements and the GPIO you would:

a) Issue a _____ to make the instrument a talker.

b) You would issue a _____ to make it a listener.

Hint: Assume the HP-IB Interface Card is set to select code 7.

Table 8-2. ASCII Characters and their 5 Bit Equivalents

ASCII CHARACTER		5 BIT DECIMAL VALUE
TALK	LISTEN	
@	SP	00
A	!	01
B	"	02
C	#	03
D	$	04
E	%	05
F	&	06
G	'	07
H	(	07
I	)	09
J	*	10
K	+	11
L	,	12
M	-	13
N	.	14
O	/	15

ASCII CHARACTER		5 BIT DECIMAL VALUE
TALK	LISTEN	
P	0	16
Q	1	17
R	2	18
S	3	19
T	4	20
U	5	21
V	6	22
W	7	23
X	8	24
Y	9	25
Z	:	26
[	;	27
\	<	28
]	=	29
^	>	30

EXAMPLE: A 9825A with HP-IB card having a select code of 7 issuing a wrt 703 would make an instrument listen if it has # for a listen address. A red 703 would cause the same instrument to talk.

LOADING AND PRINTING OUT ARRAY DATA

2. Load an Array with consecutive numbers.

EXAMPLE: A 3 row, 4 column array would be like this:

1	2	3	4
5	6	7	8
9	10	11	12

Then printout the numbers as they would appear in the array, e.g.,

```
1   2   3   4
5   6   7   8
9   10  11  12
```

Dimension your array to have the general form A(X,Y) and construct your program so X and Y can be entered from the keyboard. The 9825A allows you to use this general form that is, A(X,Y) where the 9830A/B does not.

HINTS: The tricky part is to get the printout in the above form without using the matrix ROM. In the 9830A/B there are at least 3 ways to do this. In the 9825A there is one (maybe more) good way to do this plus having the program in the general form as required above.

Techniques #1, #2, #3 show three ways of solving this problem using the 9830A/B. Try converting these techniques to 9825A HPL language. Some will work, some won't. Try to understand why or why not.

LOADING AND PRINTING OUT ARRAY DATA — 9830A/B

TECHNIQUE #1: USING THE PRINT STATEMENT

```
10  INPUT X,Y      Input two variables: X will be rows, Y will be columns.
20  N=1            Set counting variable to one
30  DIM A[20,20]   Would like to say DIM A[X,Y]. Can't do this on 9830A but can on 9825A.
40  FOR I=1 TO X
                   Nested FOR - NEXT
50  FOR J=1 TO Y
60  A[I,J]=N       Set cell 1,1 to 1; cell 1,2 to 2 etc.
70  N=N+1          Increase counting variable by 1
80  PRINT A[I,J];  Prints contents of array cell with "narrow" spacing
90  NEXT J         Loops
100 PRINT          Provides CR/LF to dump printer buffer. This completes 1st row.
110 NEXT I         Loops
120 END
```

PRINT OUT FOR X=7 AND Y=8

1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56

LOADING AND PRINTING OUT ARRAY DATA — 9830A/B

TECHNIQUE #2: USING THE OUTPUT STATEMENT

```
10  INPUT X,Y      X is # of rows and Y is # of columns.
20  N=1            Sets up counting variable
30  DIM A[20,20]   Would like to say DIM A[X,Y]. Can't do this in 9830A.
40  FOR I=1 TO X
                   Nested FOR - NEXT
50  FOR J=1 TO Y
60  A[I,J]=N       Set cell 1,1 to 1; cell 1,2 to 2 etc.
70  N=N+1          Increases counting variable by 1
75  FORMAT F3.0
                   Outputs array cell value to printer (S. Code is 15) with CR/
                   LF suppressed.
80  OUTPUT (15,75)A[I,J];
90  NEXT J         Loops
100 PRINT          Provides CR/LF to dump printer buffer. This completes 1st row.
110 NEXT I         Loops.
120 END
```

PRINT OUT FOR X=7, Y=8

1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56

LOADING AND PRINTING OUT ARRAY DATA — 9830A/B

TECHNIQUE #3: USING STRING VARIABLES

```
10  INPUT X,Y
20  N=1
30  DIM A[20,20],A$[50]   Would like to say DIM A [X,Y]. Can't do this
                          in 9830; but can in 9825A.
40  FOR I=1 TO X
50  FOR J=1 TO Y
60  A[I,J]=N
70  N=N+1
80  OUTPUT (A$[3*J-2,3*J],*)A[I,J];   Put array cell contents into string A$. Position
                                      controlled by FOR — NEXT.
90  NEXT J
100 PRINT A$   Prints content of A$ and then outputs A CR/LF.
110 NEXT I
120 END
```

PRINT OUT FOR X=7 AND Y=8

1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56

3. The following 9830A/B program outputs the FOR . . . NEXT loop number squared to the 59304A and centers it in the display window of the numeric display. This display is set to a listen address of 8. The 5 bit decimal equivalent is 24. Convert this program so it will run on the 9825A.

```
10  CMD "?U8"
20  FOR J=1 TO 5
30  FORMAT F3.0, 5X
40  OUTPUT (13,30)J↑2
50  WAIT 3000
60  NEXT J
70  OUTPUT (13,30)
80  CMD "?"
90  END
```

4. The following 9830A/B program has the 59309A clock sending to the 9830A/B calculator calendar and time information. This information is stored in A$ and then A$ is displayed and printed by the 9830A/B calculator. Convert this program to a 9825A program. Clock has a talk-listen address of P/0.

```
10  DIM A$[50]
20  CMD "?P5"
30  FOR J=1 TO 5
40  ENTER (13,*)A$
50  DISP A$
60  PRINT A$
70  WAIT 3000
80  NEXT J
90  END
```

NOTES: A "?" in your printout indicates the 59309A is uncalibrated or running with a timebase error. This is the normal condition after powerup. This same condition is indicated visually by "decimal points" in the clock display. To remove the "?" and "decimal points" open the swing door on the front of the clock and press "RESET" which will set the clock to

01	01	00	00	00
M	D	H	M	S

5. The following 9830A/B program controls a 3495A scanner and a 3455A DVM. This system scans thermistors as set up by the instructions and prints out their equivalent temperature in degrees C. Convert this program to run on the 9825A using GEN. I/O.

```
10  DISP "ENTER START CHANNEL";   Allows user to define start channel.
20  INPUT X   Data input via keyboard.
30  DISP "ENTER STOP CHANNEL";   Stop channel.
40  INPUT Y   Stop channel.
50  DISP "ENTER STEP SIZE";   Sets up for next step size
60  INPUT Z
70  FOR J=X TO Y STEP Z   Defines complete for . . . next loop
80  CMD "?U)"   9830A/B computer is "talker", 3495A scanner is "listener".
90  FORMAT F3.0   F3.0 is needed as scanner channels are 03,04 etc. Also space
                  for a + sign.
100 OUTPUT (13,90)J   Scanner closes channel that is for . . . next no.
110 CMD "?U6", "F4R4A0T1" , "?V5"   "9830 talk-3455 listen" "set up and take a kilohm
                                    reading on range 100", "3455 talk-9830 listen"
120 ENTER (13,130)A   Bring reading from 3455 into "A" in the 9830.
130 FORMAT E13.0   Line 130 sets up a field to handle reading. A field, "E" or "F", 13 or 14
                   units long is ok. Anything else is too long or too short.
140 C=3807/(LOGA+2.48)—273   Convert ohms into degrees centigrade.
150 PRINT "CHANNEL NO."J;"IS"C;"DEG C"   Print for - next # and correspond-
                                         ing temperature.
160 NEXT J   Repeat loop
170 CMD "?U)", "C"   Open all channels in 3495A scanner
180 CMD "?U"
190 FORMAT 2B   These three lines momentarily pull the ren (remote enable bus
                mgt.) line high which puts 3455 into local but does not disable
                bus.
200 OUTPUT (13,190)1024,768;
210 END   End
```

6a. This 9830A/B program measures power line frequency in relation to 60 Hz. (You can use a low voltage transformer to obtain a small 60 Hz signal.) Readings are then placed into an array. The measurement loop cycle number is displayed along with the array cell (bin) number and the actual frequency reading. Convert this program to run on the 9825A.

HINTS: In the 9825A arrays are initialized to zero when they are dimensioned. Since the 9825A is so fast and the display is double buffered you may want a 1 sec wait statement after the display statement to slow things down. Try it both ways.

HISTOGRAM OF POWER FREQUENCY STABILITY

10	DIM A(80)	Dimensions 80 cell array
20	FOR J=1 TO 80	Sets up loop to "initialize" array
30	A(J)=0	Initializes each cell in array to zero. This is needed because later in the program (line 150) we take an old array cell value and increase it by 1. Each cell must be originally set to 0 or 9830 will give error at line 150.
40	NEXT J	Loop repeats 80 times to put a 0 into each array cell
50	CMD "?U*", "I2E8G>E9I1", "?J5"	9830 talk, 5345 listen as set up to remote program initialize, 10 ms gate, hold, then take reading and reset; J5 sets 5345 to talk and 9830 to listen.
60	ENTER (13,*)B	A reading, I.E. the first reading of all zeros is put into "B". Note this is outside of loop.
70	FOR N=1 TO 500	Sets up for 500 measurement cycles.
80	CMD "?U*", "J1", "?J5"	9830 talk, 5345A listen, J1 says "take a reading", then 5345 talk, 9830 listen.
90	ENTER (13,*)B	Put reading into "B"
100	Y=INT((B-49.959)/0.001)	Normalize reading against 50 Hz.
110	IF Y > 1 THEN 130	Tests measured reading to see if it is below bottom of histogram limit.
120	Y=1	If reading is below limit set it equal to 1
130	IF Y< 80 THEN 150	Similar test against histogram upper limit
140	Y=80	Make all reading above upper limit equal to upper limit.
150	A(Y)=A(Y)+1	Takes old array value and increments it by one. If array had not been initialized to zero (lines 10 thru 40), then there would be no "old value" in array.
160	DISP N; "BIN#" Y; "1S"B; "HZ"	Displays cycle #, bin #, and frequency.
170	NEXT N	Repeats measurement loop.
180	CMD "?U*", "I2I1"	Go to local
190	END	

6b. If time permits, add the following 9862A plotting routine to your histogram experiment.

```
17:  scl 0,80,0, 100
18:  axe 0,0,1,5
19:  plt 40,0
20:  plt 40,100,-3
21:  plt 60,95
22:  lbl "HISTOGRAM OF POWER"
23:  cplt -18,-1
24:  lbl "FREQUENCY STABILITY"
25:  for J=1 to 80
26:  plt J-1, A[J]
27:  plt J,A[J]
28:  next J
29:  pen
30:  wrt 710, "I2I1"
31:  end
```

7. FORMATTING DATA FROM AN EXTERNAL DEVICE

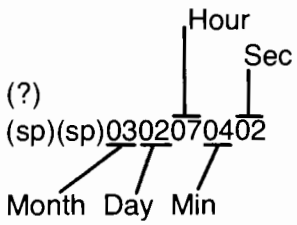
Often it is useful to bring in information from an external device and include it with mainline program information. As an example, read the current time from the 59309A ASCII CLOCK into a string, A$, check for a time error, i.e., a "?" in position A$ (1,1) and if a time error exists, reset the clock to Jan. 3, with a time of 7 hours, 4 minutes and 2 seconds.

Next, take the clock information as it is and print it out on two lines. Include the words "Date" and "Time" as shown below:

Date: 01/03
Time: 07/04/02

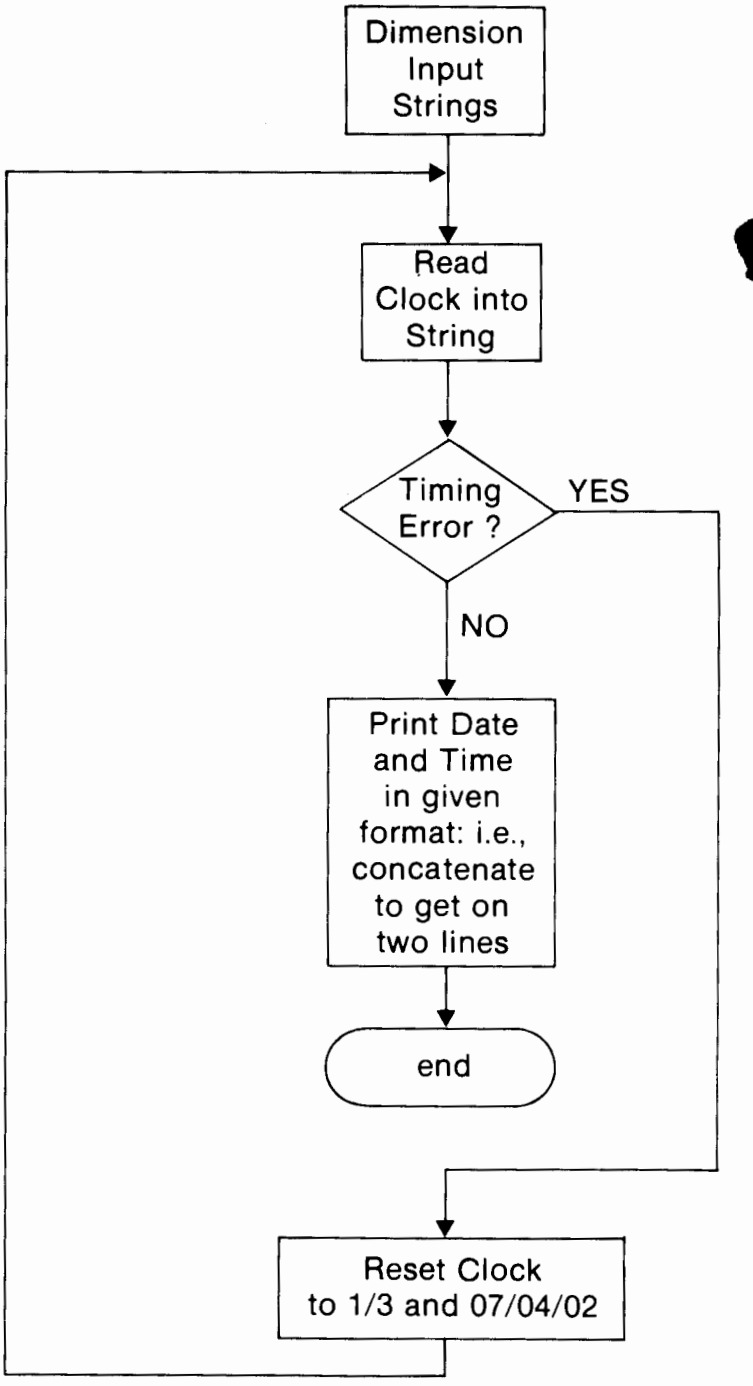
HINT: Use the "&" symbol instead of commas to concantenate (join) the text and the strings.

Assume the clock is set to talk/listen address of P/0 which has a 5 bit decimal equivalent of 16. In packed format the clock outputs a data string in this form:



P Stops the clock
T Starts the clock
R Resets the clock to 01:01:00:00:00
S Updates counting chain 1 second
M Updates counting chain 1 minute
H Updates counting chain 1 hour
D Updates counting chain 1 day

EXAMPLE:
With packed format the program line: wrt 716, "RDHMST" would set the clock to Jan. 2, 1 Hour, 1 Min, and 1 Sec. and start the clock.


Dimension Input Strings
Read Clock into String
Timing Error ?
YES
NO
Print Date and Time in given format: i.e., concatenate to get on two lines
end
Reset Clock to 1/3 and 07/04/02
Computer Museum

8. SORTING ARRAY DATA

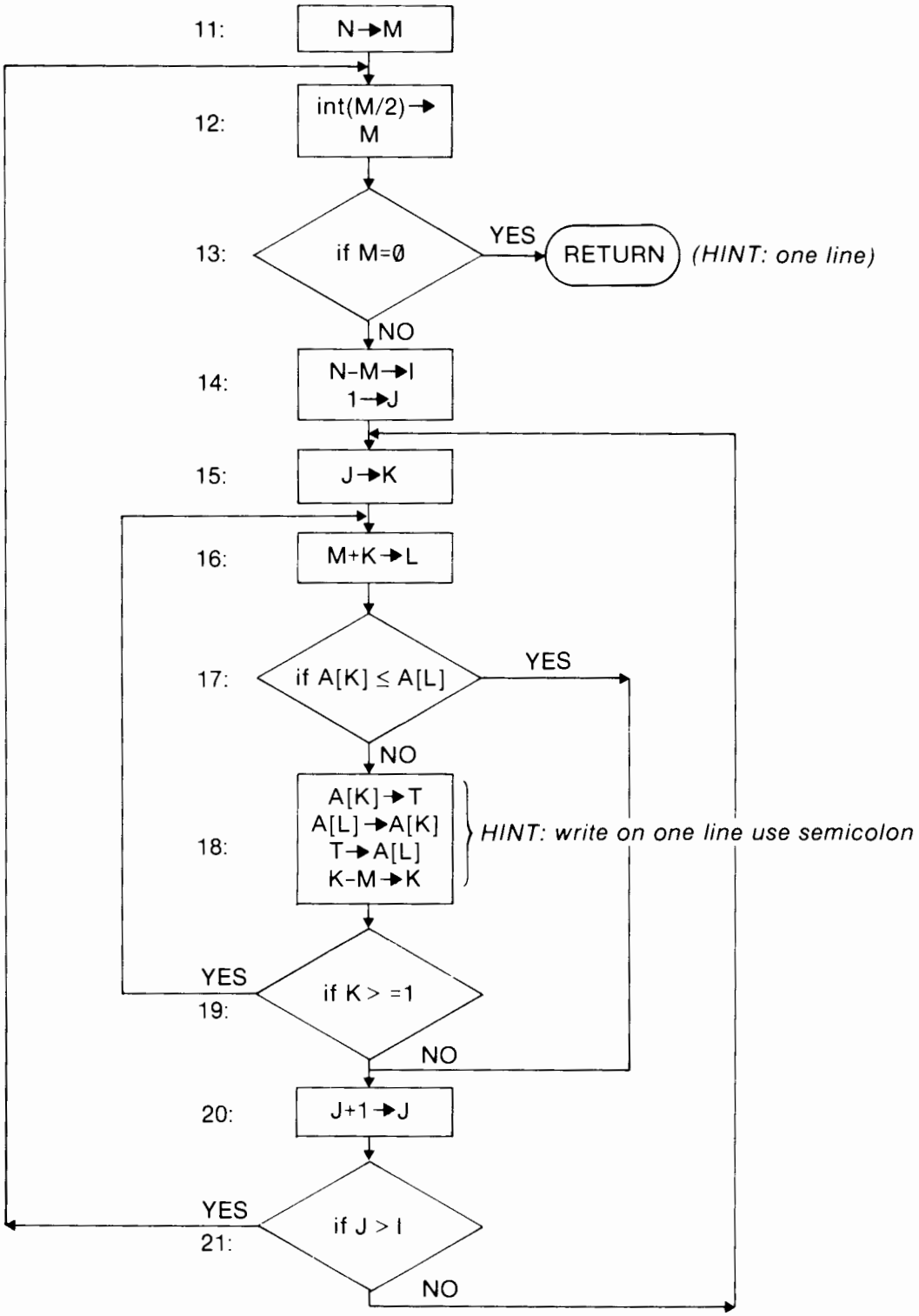
Often it is necessary to rearrange array data and put the array numbers into ascending order, i.e.: lowest number first, etc.

The 9825A does this job exceedingly quickly and the program fragment shown below fills an array with random numbers. The accompanying flow chart shows how to sort the array. Using this flow chart expand the given program to sort the array.

This technique is known as Shell's method of diminishing increment sort.

```
0:   dim A [15]
1:   for I=1 to 15
2:   rnd (0)→A[I]; prt A [I]
3:   next I
4:   15→N; spc 2
5:   gsb "sort"
6:   for I=1 to N
7:   prt A[I]
8:   next I
9:   end
10:  "sort":
     (your code)
```

If time permits change the "15" in lines 0, 1, and 4 to 1000 and take out the prt statement in 2 and time how long it takes the 9825A to sort.


11:
N→M
12:
int(M/2)→M
13:
if M=Ø
YES
RETURN
(HINT: one line)
NO
14:
N-M→I
1→J
15:
J→K
16:
M+K→L
17:
if A[K] ≤ A[L]
YES
NO
18:
A[K]→T
A[L]→A[K]
T→A[L]
K-M→K
HINT: write on one line use semicolon
YES
19:
if K > =1
NO
20:
J+1→J
YES
21:
if J > I
NO

Chapter 9 WORKSHOP PROBLEM ANSWERS

1. a) red 720 b) wrt 720

2a.
```
0:  ent X,Y
1:  dim A[X,Y]
2:  1→N
3:  for I=1 to X
4:  for J=1 to Y
5:  N→A[I,J]
6:  prt A[I,J]
7:  N+1→N
8:  next J
9:  prt
10: next I
11: end
```

FOR X=3 AND Y=4. This program doesn't work as requested. The print out for A(3,4) will be:

```
 1.00
 2.00
 3.00
 4.00
 5.00
 6.00
 7.00
 8.00
 9.00
10.00
11.00
12.00
```

2b.
```
0:  ent X,Y
1:  dim A[X,Y]
2:  1→N
3:  fmt 1,f2.0, z
4:  for I=1 to X
5:  for J=1 to Y
6:  N→A[I,J]
7:  wrt 16.1, A[I,J]
8:  N+1→N
9:  next J
10: wrt 16
11: next I
12: end
```

This program will not work at all as the 9825A strip printer does not have the same buffer arrangment as the 9866 so with CR/LF suppressed (the "Z" in 3) the printer (S. Code 16) never receives data. However, if line 7 were changed to wrt 6.1, A[I,J] and line 10 changed to wrt 6 - the 9866 has S. Code 6 — it would work on 9866.

2c.
```
0:  fxd 0
1:  ent "X=?", X, "Y=?",Y
2:  dim A[X,Y],A$[50]
3:  1→N
4:  for I=1 to X
5:  for J=1 to Y
6:  N→A[I,J]
7:  N+1→N
8:  str (A[I,J])→A$[3J-2,3J]
9:  next J
10: prt A$
11: next I
12: end
```

This pg is somewhat similar to #3 for the 9830A/B, "fxd0" in line 0 is needed otherwise the numbers 0 thru 9 will have a decimal point after the number when A$ is printed. The str statement in 8 puts the number value of A[I,J] into a quote field so it can be put into A$. You could not have put A[I,J] in directly. Using the values X=4 and Y=5 the printer output is:

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20

3.
```
0: fmt 1,f3.0,5x   sets fmt to fixed pt 3 char wide and no digits to the right of
                   decimal pt 5x outputs 5 spaces
1: for J=1 to 5    sets FOR..NEXT for 5 cycles
2: wrt 724.1,J↑2   sends FOR..NEXT loop number squared to the numeric display
3: wait 3000       waits 3 seconds
4: next J          increments FOR..NEXT loop
5: wrt 724         blanks the Numeric Display
6: wrt 725         turns off listening light as you can only have one listener with GP/IO
7: end
```

4.
```
0: dim A$[50]      dimensions a 50 character array
1: for J=1 to 5    sets up loop for 5 cycles
2: red 716,A$      reads data from clock into A$
3: dsp A$          displays A$
4: prt A$          prints A$
5: wait 3000       waits 3 seconds
6: next J          loops
7: end
```

```
5.  Ø:  ent "Start Channel", X
    1:  ent "Stop Channel", Y
    2:  ent "Step Size", Z
    3:  for J=X to Y by Z
    4:  fmt 1,f3.Ø
    5:  wrt 7Ø9.1,J
    6:  wrt 722, "F4R4A0T2T3"
    7:  fmt 2,f13.3
    8:  trg 722; red 722.2,A
    9:  38Ø7/(ln(A)+2.48)-273→C
    1Ø: prt "Chan.#", J, "is", C, "Deg C"; spc 2
    11: next J
    12: wrt 7Ø9, "C"; lcl 722
    13: end
```

NOTE: fmt 1,fz2.0 would also work — the "z" inserts leading zeros.

— This is preferred, see page 3-3.

NOTE: "Free-field" format would also work here. Thus line 7 could be eliminated and line 8 would read trg 722; red 722,A.

NOTE: This program would be more efficient, i.e. execute faster, if lines 4, 6 and 7 were outside the loop. A good place would be just before the for — — next loop.

```
6a. 0:  dim A[8Ø]
    1:  wrt 71Ø,"I2E8G>E9I1"
    2:  red 71Ø,B
    3:  for N=1 to 1ØØ
    4:  wrt 71Ø,"J1"
    5:  red 71Ø,B
    6:  int ((B-59.959)/.ØØ1)→Y
    7:  if Y>1; gto 9
    8:  1→Y
    9:  if Y<8Ø; gto 11
    1Ø: 8Ø→Y
    11: A[Y]+1→A[Y]
    12: fmt 1, "Cycle No.", f3.Ø, " Bin# ", f2.Ø, " is ", f6.3, "Hz"
    13: wrt .1,N,Y,B
    14: wait 1ØØØ
    15: next N
    16: wrt 71Ø, "I2I1"
    17: dim A$[14]
    18: for J=1 to 14; "*"→A$[J,J]; next J
    19: max (A[*])→Q
    2Ø: fmt 2,f2.Ø, c14
    21: for J=1 to 8Ø
    22: wrt 16.2,J,A$[1,14int(A[J])/Q]
    23: next J
    24: prt "HISTOGRAM OF POWER
        FREQUENCY STABILITY"
    25: spc 2
    26: end
```

NOTE: This is really wrt Ø.1 but leading zeros are suppressed in listings. Try deleting line 14 (the wait statement) and see how fast the 9825A processes data.

7.
```
0:  dim A$[16]
1:  fmt ;red 716,A$
2:  if A$[1,1]="?";gto "error"
3:  prt "Date: "&A$[3,4]&"/"&A$[5,6]
4:  prt "Time: "&A$[7,8]&"/"&A$[9,10]&"/"&A$[11,12]
5:  end
6:  "error":wrt 716, "RDDHHHHHHHMMMMSS";gto 1
```

8.
```
0:  dim A[15]
1:  for I=1 to 15
2:  rnd(0)→A[I];prt A[I]
3:  next I
4:  15→N;spc 2
5:  gsb "sort"
6:  for I=1 to N
7:  prt A[I]
8:  next I
9:  end
10: "sort":
11: N→M
12: int (M/2)→M
13: if M=0;ret
14: N-M→I;1→J
15: J→K
16: M+K→L
17: if A[K]< =A[L];gto +3
18: A[K]→T;A[L]→A[K];T→A[L];K-M→K
19: if K> =1;gto -3
20: J+1→J
21: if J> I;gto 12
22: gto -7
```