PACIFIC MEASUREMENTS INC.

APPLICATION NOTE NUMBER AN 19

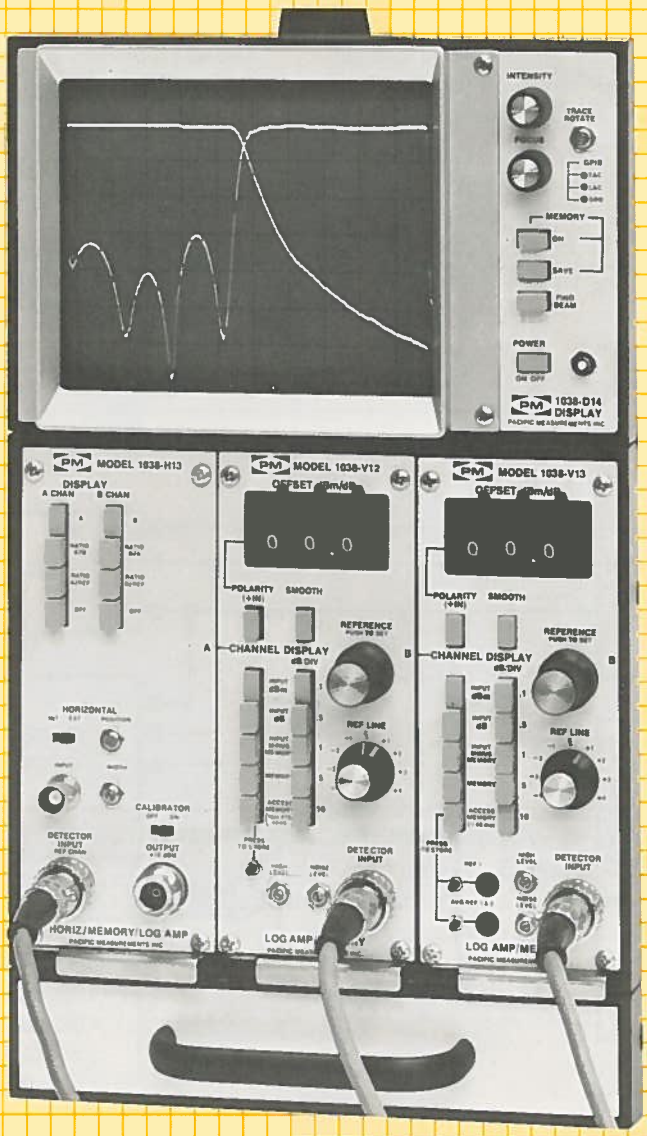
Programming the Model 1038-D14 Swept Measurement System

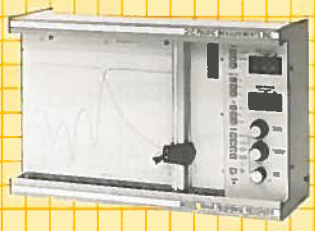
(with optional built-in General Purpose Interface Bus—GPIB)

GET ON THE BUS
WITH YOUR MODEL 1038 SWEPT ANALYZER

THIS APPLICATION NOTE WILL TELL YOU HOW:

- To Control the 1038 Display
- To Read from the Display
- To Write to the Display
- To Read from the 1038 Plug-In Units
- To Write to the 1038 Plug-In Units
- To Read a Single Data Point
- To Perform a Quick "Self-Test" of the Interface Board





THIS PUBLICATION CONTAINS SAMPLE PROGRAMS TO START YOU ON YOUR WAY

INTRODUCTION

The addition of the General Purpose Interface Bus (GPIB) to the Pacific Measurements Model 1038-D14 Swept Measurement System adds even more capacity to one of the most versatile and reliable measurement systems on the market. When equipped with the GPIB, the 1038-D14 can exchange information with external computers, calculators, or up to fourteen other devices on the bus as required. The GPIB option provides the capability of remotely reading or writing to or from a CRT display memory, and reading or writing data into and back out of the measurement system plug-ins (including the plug-in Auto Memory).

The GPIB option includes a microprocessor and its associated read-only and random access memories. This allows the bus to transmit or receive a complete set of data all at once. For example, when it is desired to have the 1038-D14 send data over the bus, it is first commanded to transfer the data to the bus interface memory. A subsequent command provides each data point by including its horizontal location as part of the command.

The interface bus assembly physically consists of a single circuit board installed at the bottom of the swept analyzer unit. A standard interface connector and the analyzer address switches are accessible at the bottom rear panel.

IF YOUR 1038-D14 UNIT IS NOT EQUIPPED WITH THE GPIB (OPTION 04), YOU CAN EASILY ADD THIS CAPABILITY WITH A FIELD INSTALLABLE KIT OR, IF DESIRED, THE UNIT CAN BE RETURNED TO THE FACTORY FOR GPIB INSTALLATION AND TESTING.

At the end of this Application Note will be found suggested programs for controlling the operation of the GPIB. Separate sets of programs are listed for the Tektronix Model 4051 Calculator and the Hewlett-Packard Model 9825A Calculator. These calculators are given as examples of controlling devices because they are among those in the most general usage. They also contain the required I/O and programming characteristics. In actuality, almost any programmable calculator with IEEE I/O capability could be used to control the bus.

GENERAL OPERATION OF THE BUS ASSEMBLY

(See the block diagram, Figure 1, for signal routing to and from the bus assembly.)

The bus data for the CRT display is digital and transmitted over a multi-line internal bus between the IEEE bus and the refresh display memory. Data for the plug-in modules is in analog form and is transmitted over a single wire for each channel and direction. An analog-to-digital converter on the bus assembly converts input voltages to digital data and vice versa.

The microprocessor is programmed to convert binary data to the ASCII format for transmission on the bus. Data from the bus to the plug-ins is converted to analog and automatically ratioed with the plug-in input signal. The ratio is formed by subtracting the bus signal from the input signal. This is possible because both signals represent decibels.

Note: The GPIB board uses the external ratio input to transmit analog data to the plug-ins. For this reason, the

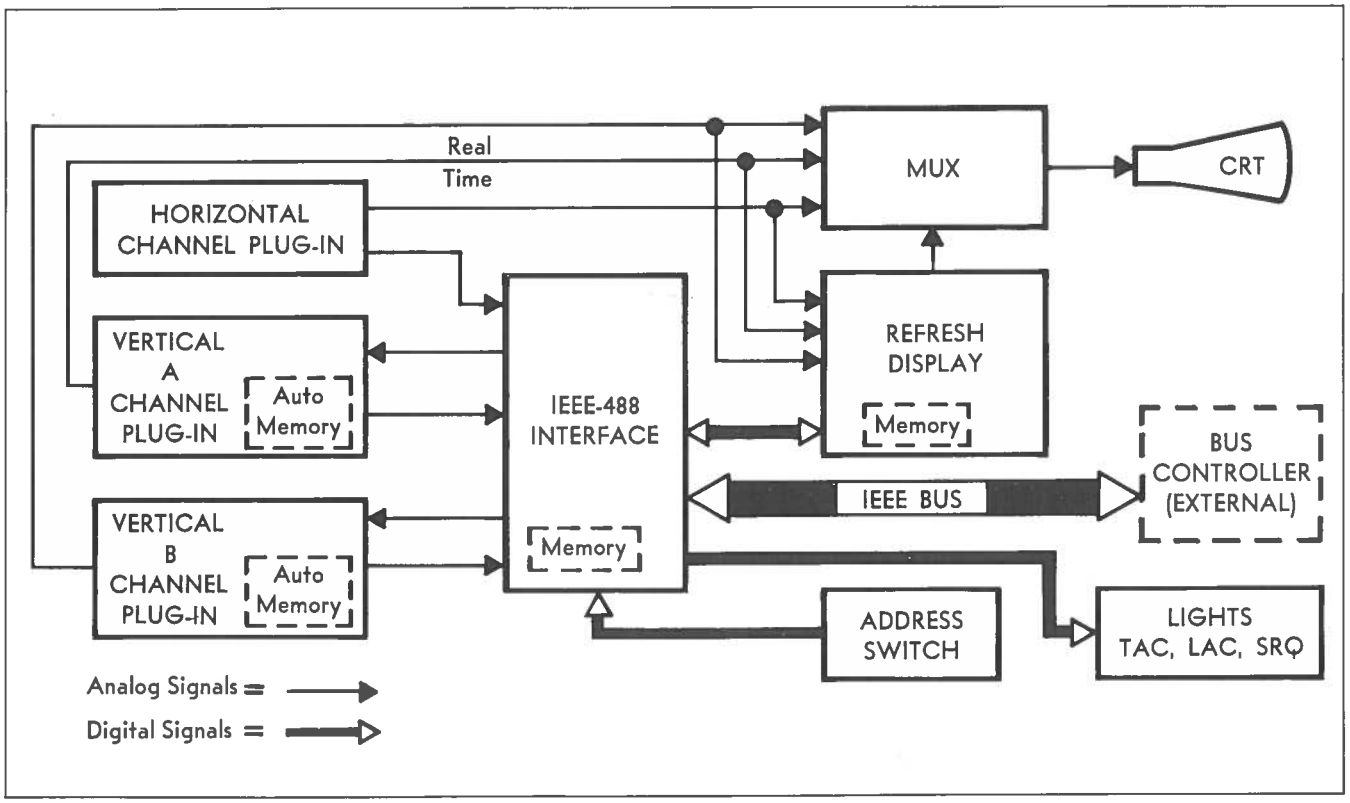


Figure 1 — Model 1038-D14 GPIB Block Diagram

external ratio function of the unit cannot be used when the instrument is GPIB equipped. Provision must also be made to supply the horizontal plug-in with an external sweep input as the memory will not operate with internal sweep.

INITIAL SET-UP OF THE BUS INTERFACE

To use the bus, first interconnect the standard bus cable from the 1038-D14 unit to the controller and any other instruments to be included in the bus configuration. Next to the bus connector on the rear of the D14 is located an address selector switch. It is used to select the talk and listen address for the unit. Both addresses are identical and are set with the same switch position. See Figure 2 for an explanation of the address switch positioning. Programming examples given later in this publication assume that address 4 has been selected.

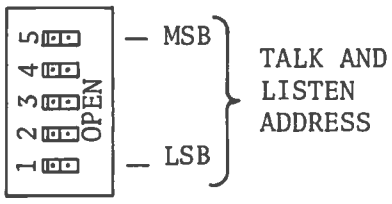
GENERAL PROGRAMMING REQUIREMENTS

The initial function of the bus interface when it first receives data is to read the data and interpret the command. Regardless of the type of data sent on the bus, certain requirements must be met in implementing the program. These requirements include:

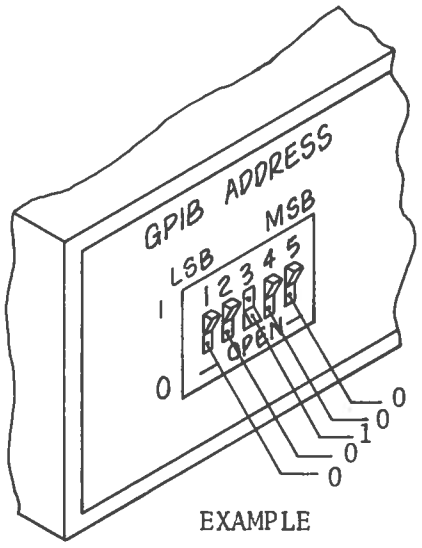
1. Transmission of either a "Device Clear" (DCL) or a "Selective Device Clear (SDC) command to the address used by the 1038-D14. This should be done at the beginning of any program, before any data is sent to the D14, because the interface bus or the instrument may have been left in an unknown or arbitrary state.

2. When sending data to the D14, it is essential that it be sent in the *exact* format specified. Failure to do this can result in the instrument's program locking up and no longer responding to further commands. This can only be corrected by turning off the power for ten seconds or more, and then turning the power back on again. A series of commands can be transmitted to the instrument separated by colons if desired. A maximum of 80 characters (including the colons) can be transmitted before terminating the set with carriage return or line feed characters. A carriage return, line feed, or both will be accepted as terminating characters, but the instrument will only send a carriage return-line feed as a terminator for its data. End or identify (EOI) will be sent as a true statement coincident with the line feed character.

3. When writing to the instrument's display or plug-in units, all 512 discrete items of data should be utilized to fill all possible memory locations. If this is not done, any unwritten memory will contain undesired information which will show on the display or be ratioed to the plug-in units. If 512 data points are not initially available,



GPIB ADDRESS (S4)



EXAMPLE

To set a true value for a bit, the corresponding switch must be closed. To do this, press down on the small dimple closest to the numbers "1,2,3,4,5" (A small screwdriver or ball-point pen is useful). To set a false condition, press the side closest to the legend "open."

Example: Assume it is desired to set the following condition on switch S4:

Listen Address = 4 (binary 00100)

To do this, set 1,2,4 and 5 open, and bit 3 closed.

Figure 2 — Option 04 IEEE 488 Interface Selector Switch Operation

interpolation should be made between points to assure that all available memory is used. An exception to this action can be made if the display beyond the edges of the CRT graticule (which would contain the undesired information) can be disregarded. In this case, at least 501 data points must be sent to fill the area within the graticule with valid information.

The three lights on the front panel of the 1038-D14 are used as an aid to debugging programs. They indicate that the instrument is functioning either as a TALKER (TAC), a LISTENER (LAC), or that it has data ready and is requesting action by the controller (SRQ). If a character string is received which cannot be recognized, all three of these lights will flash for about one second.

CONTROLLING THE DISPLAY

Two buttons on the front of the 1038-D14 control the refresh memory display and memory update during each sweep of the display trace. Both buttons must be in the OUT position for the bus to control the display status.

The following commands control the operation of the display from the bus:

DM—Causes the refresh memory data to be displayed.

DR—Causes the refresh memory to be off (real-time display).

DS—Causes current data contained in the refresh memory to be saved (not updated).

DU—Causes the refresh memory to be continuously updated.

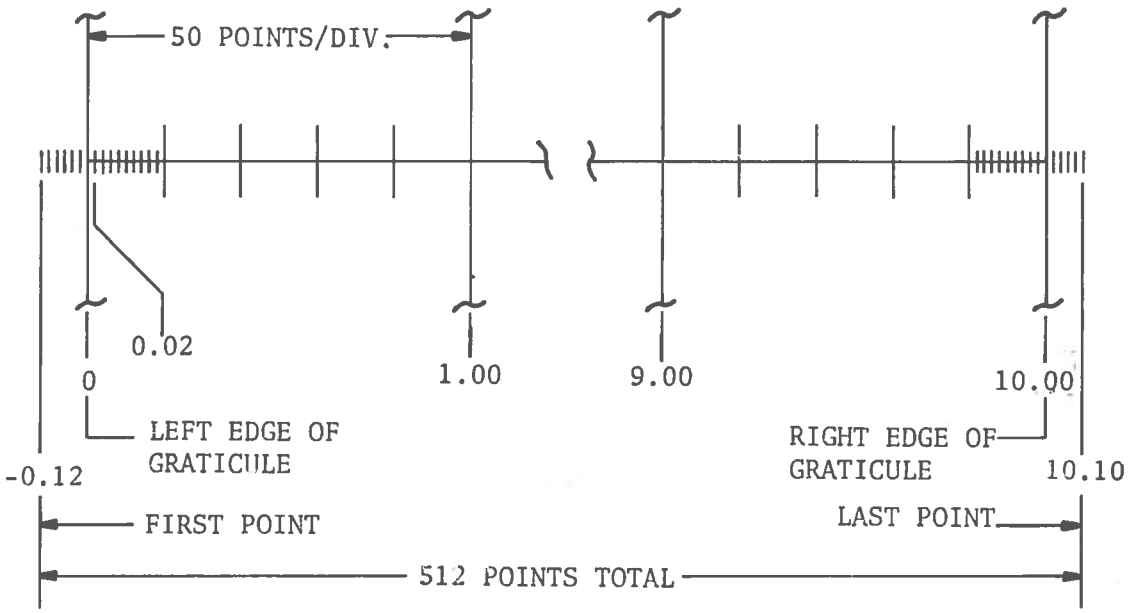
When any command is sent, it must be followed by carriage return or line feed characters. For example, to display memory and update the display, the commands can be sent:

"DM:DUcr" or "DMcrDUcr"

where "cr" denotes carriage return

READING FROM THE DISPLAY

Since real-time displays are not accessible through the bus, the refresh memory function must be used for reading or writing. This means that the display must be in the memory display mode to provide data to the bus. This function is activated by either pressing the MEMORY ON button on the instrument or transmitting a "DM" through the bus interface. The usual procedure is to also transmit a "DU" command to allow new data to be written into the display memory prior to accessing it from the bus. Sufficient time must be given after the "DM" and "DU" commands are transmitted to allow one complete sweep of the trace across the CRT. This time is required to allow the memory to fill with data.



Horizontal coordinates used to establish location relative to the CRT graticule. The horizontal coordinate is specified for the format "±XX.XX". When sending to the D14, only negative values require a sign. For values less than one, at least one zero to the left of the decimal point is required. Odd horizontal positions get rounded down(5.03→5.02)internally. Since there are fifty discrete memory locations per division, the hundredths digit will always be even, except for the data transmitted in response to the "RE" command, as this command does not relate to memory location.

Figure 3 — Horizontal Coordinates

To transmit data from the display, the data must first be transferred to the GPIB memory. Depending on whether A or B channel data is desired, either a "DA" or a "DB" command must be sent to the 1038-D14. Transmitting the command "DV±XX.XXcr" will cause the D14 to subsequently send the value of the displayed channel at the location specified by the X-coordinate. The value will be shown in divisions, with the horizontal center line of the graticule corresponding to 0. As soon as the D14 is addressed as a talker, it will transmit the requested data in the format "±Y.YYcr". The maximum range of vertical values is ±4.38 divisions, a value allowing readings a little beyond the edge of the screen. If the X-coordinate is a positive value, no sign need be transmitted. For values less than one, a zero to the left of the decimal point is required. The horizontal resolution is 0.02 divisions. If an odd address should be given (e.g., 5.01 div), the value returned will be for the next lower address.

The 512 data points in storage are arranged so that up to 50 points can be indicated for each major division of the display graticule. The left edge of the graticule is location 0.00 and the right edge is location 10.00. Including the edges, 501 data points can be contained within the graticule in increments down to 0.02. See Figure 3 for a better understanding of this arrangement.

This discrete data point selection and positioning format has the advantage of allowing the user to determine precisely how much data he wants to display or how much he can place in storage. The "DA" or "DB" commands take only a few hundred milliseconds to place the desired data on display; transmission of all 512 data points will take approximately 5 to 10 seconds, depending on the controller used.

WRITING TO THE DISPLAY

To write to the 1038-D14 display, data must first be sent on the bus to the D14 from the GPIB (CPU) memory. A single command will then cause this data to be transferred to the display memory. The data format used to transmit to the D14 is "DC±XX.XX,±Y.YYcr" or "DD± XX.XX,±Y.YYcr". The "DC" and "DD" part of the command tells the instrument that the data is either for the A or for the B channel respectively. The command segment "±XX.XX" establishes the horizontal location of the data on the display as described in Figure 3. Vertical data is sent as "±Y.YY", and is displayed as discrete divisions with the horizontal center line corresponding to 0. The top and bottom lines of the display graticule correspond to + and − 4.00 divisions respectively. Information can be displayed 0.38 divisions (±4.38 divisions total) beyond the limits of the graticule. Transmitting the command "DLcr" will cause the data to be transferred to the D14 memory for display.

READING FROM THE PLUG-IN UNITS

The process of reading from the plug-in units is very similar to that used to read from the display. The data is collected in the IEEE interface board memory in the D14 during one complete horizontal sweep of the trace.

The data is then delivered to the bus, one point at a time, as it is requested. The process of collecting the data requires that each point be digitized prior to storage in the GPIB memory. Since this process requires time, it is imperative that the trace displaying the swept-frequency or swept amplitude signal be adjusted to sweep no faster than twice each second when reading plug-in data into the interface memory. This critical timing can be assured by slowing the sweep down until the display update intensity marker is visible. The marker will become visible at about one sweep per second.

Sending the "RA" or "RB" command on the bus will cause the D14 to collect the data from the A or B channel plug-in units, respectively. The D14 will sense the data contained in one complete left to right sweep of the trace. If a sweep is in progress when the "RA" or "RB" command is given, data will not be collected until that sweep is finished and the next sweep is started. Thus, it is possible for several seconds to elapse before data is available for transmission on the bus.

The command "RV±XX.XXcr" will cause the D14 to transmit the data it has collected. The D14, functioning as a talker, will transmit the plug-in data at the specified horizontal location of the display in the format "±DD. DDcr". With respect to the reference level, the data is in dB with a resolution of ±0.01 dB. The range of values is from +20.95 to −60.95 dB. If the D14 is in the midst of collecting data when it is addressed, it will complete the collecting cycle before sending any data on the bus.

WRITING TO THE PLUG-IN UNITS

Writing to the plug-in units is done in a similar manner as writing to the display. Data is transmitted to the GPIB memory using the format "RC±XX.XX,±DD.DDcr". Then, sending the commands "RHcr" or "RJcr" will cause the data in the GPIB memory to be ratioed (subtracted in dB) to the signal from the selected plug-in unit. "RH" commands a ratio function to the A channel and "RJ" ratios to the B channel. Since digital to analog conversion must take place, the sweep speed must be limited to about one sweep per second. The horizontal location is defined similar to the description given in Figure 3. Data can be sent within the range +20.00 to −60.00 dB with ±0.01 dB resolution.

Since the ratio functions "RH" and "RJ" require the use of the CPU on the GPIB assembly, any subsequent commands will interrupt the processor and stop the ratio process. Therefore, if it is desired to control the display (such as transmitting a "DM" command), this should be done before sending "RH" or "RJ". Repeating the "RH" or "RJ" command after interrupting with another command will also return the instrument to a ratio mode. Commands such as "DA", "DB", "DC", "DD", "RA", "RB", or "RC" will write over the data in the GPIB buffer memory. If one of these has been sent, it will be necessary to rewrite the "RH" or "RJ" command before the ratio function can be restored. The command "RD" will disable the ratio function without affecting any other function.

READING A SINGLE DATA POINT

If it is required that responses be read at specific frequencies, the instrument can be addressed to talk using the "RE" command. After "RE" has been sent, the D14 will transmit one group of data from the plug-in using

SUMMARY OF GPIB (IEEE 488 BUS) COMMAND CODES

CODE	FUNCTION
DA DB	Read display memory and store in interface memory Channel A (B).
DC±XX.XX,±Y.YY DD±XX.XX,±Y.YY	Write display data from GPIB to interface memory, Channel A (B).
DL	Loads display memory from interface memory.
DS DU	Display save (update) (equivalent to operating SAVE button).
DM DR	Display memory (real time) (equivalent to operating memory button).
DV±XX.XX	Read to GPIB the display memory data at horizontal position ±XX.XX as stored in interface memory by "DA", "DB", "DC", or "DD".
RA RB	Similar to DA and DB above, but reading from plug-in ratio output to interface memory.
RC±XX.XX, ±YY.YY	Write plug-in ratio data from the GPIB into interface memory.
RH RJ	Ratio Channel A (B) measurements to data stored by "RC", "RA", or "RB".
RD	Disable ratio activity of "RH" or "RJ".
RV±XX.XX	Read to GPIB the plug-in ratio data at the horizontal position ±XX.XX as stored in interface memory by "RA", "RB", or "RC".
RE	Read to GPIB plug-in ratio data output, Channel A & B ratio data values and the horizontal position value of the ratio data.

the format "XX.XX,AA.AA,BB.BBcr". A and B values are in dB, and the X value corresponds to the location on the display, as defined in Figure 3.

SELF-TEST FUNCTION

The "TA" command provides a limited self-test of the interface board, the display memory, and connecting cables. "TA" causes the IEEE interface to write information to the refresh display memory. The information is then read back to the interface and, if a true comparison is achieved, a test pattern of crossed lines or diagonals will appear on the CRT display.

LOADING THE PLUG-IN MEMORY WITH BUS DATA

The GPIB assembly has sufficient memory to provide a ratio function for one plug-in unit at a time. Also, the sweep rate must be limited to about one sweep per second. These limitations can increase the time required for completion of a test routine, but can be overcome by loading the plug-in memory with bus data.

Most applications requiring writing to plug-in units involve the sending of theoretical or desired performance curves to be compared with the actual measurement. For these cases, the system response characteristics must be independently subtracted as well. To do this, the standard data should be ratioed to the plug-in using the "RH" or "RJ" commands, and the test set-up configured for calibration with the test device absent.* The composite data is then stored in the plug-in memory by accessing the memory and pressing the STORE button on the plug-in module.

Bus data is subtracted (in dB) when the "RH" and "RJ" commands are used. Since the plug-in memory also subtracts data, it is possible for two subtractions to occur when only one is desired. To prevent this, it is essential

that the sign of the data being sent to the plug-in memory be reversed. This action assures that a correct comparison will be made between the measurement and the transmitted data. The display screen will show the difference between what was sent and what is being measured. A perfect correspondence will result in a straight line response at the display reference location.

When the input minus memory function is used with the device under test, variations from the center line reference represent gains or losses in the device.

PROGRAMMING NOTES

The horizontal address format ±XX.XX provides 512 data points from the display or plug-in units, but the display graticule is only able to contain 500 points within its limits. (Horizontal position extends from −0.12 to +10.10 divisions at 50 points per major division. See Figure 3 of this Application Note.)

The bus functions implemented include; SH1, AH1, T6, TEØ, L4, LEØ, SRØ, PPØ, DC1, STØ, CØ, SR1 (software selectable).

The data display format ±Y.YY provides 256 points of display resolution with approximately 240 points within the vertical display graticule. (Vertical positions extend from +4.38 to −4.38 divisions.)

The ratio data format ±YY.YY provides 0.01 dB resolution (vertical dB values extend from +20.95 to −60.95 dB).

Commands can be linked together in series if they are delimited with colons. A command string must be terminated by "CR" or "LF", and must be less than 80 characters long (including the colons).

Commands which cause continuous activity (e.g. RH, RJ, and certain test commands) will cease execution when the D14 interface is sent another command or is addressed to talk. Continuous activity commands cannot be effectively followed by a colon and additional commands, but can be preceded by other commands.

If the D14 bus interface does not "understand" a received data sequence, the TAC, LAC, and SRQ lights will flash momentarily. The bus interface can recover from most programming errors. If it does not recover, it may be necessary to turn off the power for at least 10 seconds and then back on again.

PROGRAM CONFIGURATION INFORMATION

The Model 1038-D14 Option 04 Interface Bus Printed Circuit Board (PCB) Assembly #14180 is identified with a code number label. This label is located adjacent to the PCB Assembly number on the component side of the board. The code number identifies the code revision level of the assembly and the specific programming of the two Programmable Read Only Memory (PROM) devices, U25 and U26, used in the assembly. The programs listed in this Application Note assume a code number of 101-B. These programs will be compatible with 101-B and subsequent revisions. The programs may not fully exploit the capabilities of the later PROM's, but they will work. If you have further questions or problems, please contact the Pacific Measurements Customer Service Department.

* *Calibration procedures are discussed in Pacific Measurements Application Note AN 20.*

PROGRAMS FOR THE TEKTRONIX MODEL 4051 CALCULATOR

The following program allows the operator to interactively control the D14 through the Tektronix Calculator's keyboard. The device address is "4".

```
1 REM D14 KEYBOARD COMMAND ENTRY
2 REM PUSH USER KEY 1 TO START
3 REM THEN ENTER DESIRED COMMAND
4 GO TO 100
100 ON SRQ THEN 500
105 WBYTE @20;
110 PRINT "COMMAND"
120 INPUT A$
130 IF A$="DCL" THEN 400
132 IF A$="RH" THEN 200
134 IF A$="RJ" THEN 200
136 IF A$="TF" THEN 200
138 IF A$="TG" THEN 200
140 IF A$="TH" THEN 200
142 IF A$="TI" THEN 200
144 IF A$="TJ" THEN 200
146 IF A$="TK" THEN 200
148 IF A$="TL" THEN 200
150 IF A$="TM" THEN 200
152 IF A$="TN" THEN 200
154 IF A$="TP" THEN 200
156 IF A$="TR" THEN 200
160 PRINT @4;A$
170 INPUT @4;B$
180 PRINT B$
190 GO TO 110
200 PRINT @4;A$
210 GO TO 110
400 WBYTE @20;
410 GO TO 110
500 POLL A,B;4
510 PRINT "POLL RESPONSE",A,B
520 GO TO 110
```

Listing of Keyboard Commands Entry Program

Program 1

Statement 120 inputs the command string from the keyboard. Statement 160 sends the same string to the D14. Statement 170 receives data from the D14 and statement 180 writes the data to TEK display. WBYTE @20: causes a "device clear."

Statements 100 and 500 implement serial polling if an "SE" command has been sent to the D14.

The following program uses the "DC" and "DD" commands to plot sine and −sine data to the D14 display. The data is sent to the D14 interface in statements 230 and 240. The data is then loaded into the D14 display memory in statement 270. Statement 280 waits in order to maintain the remote status of the D14. When the program "breaks," the D14 will revert to local status. The operator should manually operate the memory save button to save the display.

```
4 GO TO 190
100 REM SINE AND -SINE PLOT ON D14
110 REM PUSH USER KEY 1 TO START
190 WBYTE @20;
200 FOR I=1 TO 500
210 J=2*PI*I/250
220 B=4*SIN(J)
230 PRINT @4; USING 260;"DC";I/50;B
240 PRINT @4; USING 260;"DD";I/50;-B
250 NEXT I
260 IMAGE2A,2D.2D,",",2D.2D
270 PRINT @4;"DL"
280 WAIT
```

"Listing of "DC" and "DD" Command Display Program.

Program 2

The program shown below transfers the D14 display memory information to the TEK controller by using the "DV" command in statement 130. Statements after 145 replot the data on the TEK CRT display.

```
1 REM TRANSFER D14 DISPLAY TO
2 REM TEK 4051 DISPLAY
3 REM TO START PUSH USER KEY 1
4 GO TO 100
100 DIM Y(512)
102 WBYTE @20;
105 PAGE
110 PRINT @4;"DA"
120 FOR I=1 TO 512
130 PRINT @4;"DV";(I-7)/50
140 INPUT @4;Y(I)
145 NEXT I
200 WINDOW -1,11,-5,5
210 AXIS 0.5,0.5,0,0
220 AXIS 0,0,-1,-5
230 AXIS 0,0,0,-4
240 AXIS 0,0,1,-3
250 AXIS 0,0,2,-2
260 AXIS 0,0,3,-1
270 AXIS 0,0,4,0
280 AXIS 0,0,5,1
290 AXIS 0,0,6,2
300 AXIS 0,0,7,3
310 AXIS 0,0,8,4
320 AXIS 0,0,9,5
330 AXIS 0,0,10,0
340 AXIS 0,0,11,0
350 MOVE 5,0
351 PRINT "5"
352 MOVE 10,0
353 PRINT "10"
390 MOVE -0.12,Y(1)
400 FOR I=1 TO 512
410 DRAW (I-7)/50,Y(I)
420 NEXT I
430 PRINT @4;"DB"
435 FOR I=1 TO 512
440 PRINT @4;"DV";(I-7)/50
445 INPUT @4;Y(I)
450 NEXT I
460 MOVE -0.12,Y(1)
470 FOR I=1 TO 512
480 DRAW (I-7)/50,Y(I)
490 NEXT I
500 MOVE -1,-5
510 STOP
```

Listing of "DA" and "DV" Command and Plot Program.

Program 3

The following program reads plug-in data from the D14 (statements 160, 1010, and 1020) and plots the data on the TEK.

```
1 REM PROGRAM TO PLOT PLUGIN RATIO
2 REM DATA ON TEK 4051
3 REM TO START PUSH KEY 1
4 GO TO 100
100 DIM Y(512)
102 WBYTE @20;
110 PAGE
115 B$="Y"
120 GOSUB 4000
160 PRINT @4;"RA"
170 GOSUB 1000
194 GOSUB 3000
195 RMOVE -1,0
196 PRINT "CHANNEL A"
210 PRINT @4;"RB"
220 GOSUB 1000
230 GOSUB 3000
240 RMOVE -1,0
250 PRINT "CHANNEL B"
998 MOVE -1,-60
999 STOP
1000 FOR I=1 TO 512
1010 PRINT @4;"RV";(I-7)/50
1020 INPUT @4;Y(I)
1030 NEXT I
1040 RETURN
2000 IF A$="Y" THEN 2020
2010 RETURN
2020 PRINT Y
2030 RETURN
3000 IF B$="Y" THEN 3020
3010 RETURN
3020 MOVE -0.12,Y(1)
3030 FOR I=1 TO 512
3040 DRAW (I-7)/50,Y(I)
3050 NEXT I
```

```
3060 RETURN
4000 IF B$="Y" THEN 4020
4010 RETURN
4020 PAGE
4030 WINDOW -1,11,-60,20
4040 AXIS 0.5,10,0,0
4050 MOVE -0.1,-3
4051 RMOVE 1,0
4052 PRINT "1"
4053 RMOVE 1,0
4054 PRINT "2"
4055 RMOVE 1,0
4056 PRINT "3"
4057 RMOVE 1,0
4058 PRINT "4"
4059 RMOVE 1,0
4060 PRINT "5"
4061 RMOVE 1,0
4062 PRINT "6"
4063 RMOVE 1,0
4064 PRINT "7"
4065 RMOVE 1,0
4066 PRINT "8"
4067 RMOVE 1,0
4068 PRINT "9"
4069 RMOVE 1,0
4070 PRINT "10"
4100 MOVE -1,20
4110 PRINT "+20DBM"
4120 MOVE -1,-20
4130 PRINT "-20DBM"
4140 MOVE -1,-40
4150 PRINT "-40DBM"
4160 RETURN
```

Listing of "RA" and "RV" Command and Plot Program.

Program 4

The program listed below takes plug-in data via the "RE" command and prints selected data on the TEK display.

```
4 GO TO 600
8 GO TO 530
12 GO TO 100
80 REM D14 RE COMMAND
100 PAGE
105 WBYTE @20;
110 RESTORE
120 DIM X(51),A(51),B(51)
130 FOR N=1 TO 51
140 H=0.2*(N-1)
150 PRINT @4;"RE"
160 INPUT @4;I
170 F=H-I
180 IF ABS(F)<0.05 THEN 200
190 GO TO 150
200 X(N)=H
210 INPUT @4;J,A(N),B(N)
220 NEXT N
230 PRINT "DATA COLLECTED"
240 FOR Q=1 TO 200
250 NEXT Q
260 PAGE
270 WINDOW -1,10,-60,15
280 AXIS 1,10
290 MOVE -1,10
300 PRINT "+10"
310 MOVE -0.6,0
320 PRINT "0"
330 MOVE -1,-10
340 PRINT "-10"
350 MOVE -1,-20
360 PRINT "-20"
370 MOVE -1,-30
380 PRINT "-30"
390 MOVE -1,-40
400 PRINT "-40"
410 MOVE -1,-50
420 PRINT "-50"
430 D$="FD"
440 MOVE 0.1,1
450 PRINT USING D$;S
460 MOVE 9.4,1
470 PRINT USING D$;E
480 MOVE X(1),A(1)
490 DRAW X,A
500 MOVE X(1),B(1)
510 DRAW X,B
520 END
530 RESTORE
540 INIT
550 PAGE
560 PRINT "START AND END FREQUENCIES"
570 INPUT S,E
580 PAGE
590 GO TO 120
600 PAGE
610 PRINT "TO USE PROGRAM ADJUST"
620 PRINT "DISPLAY FOR A SMALL"
630 PRINT "AMOUNT OF OVERSCAN."
640 PRINT "THE SOURCE MUST TAKE"
650 PRINT "MORE THAN 20 SECONDS"
660 PRINT "PER SWEEP."
670 PRINT "PUSH USER KEY 2 TO SET"
680 PRINT "FREQUENCY SCALE."
730 END
```

Listing of "RE" Command and Print Program.

Program 5

PROGRAMS FOR THE HEWLETT-PACKARD MODEL 9825A CALCULATOR

The following program calculates two sine curves shifted by 90°, then transmits them to the interface memory of the D14. When transmission is complete, the "DL" command is sent to transfer the data to the display memory and cause the curves to be displayed.

```
0: "Writes sin & Cos to memory.";
1: "3 April 1980";
2: fmt 1,"DC",f5.2,",",f5.2
3: fmt 2,"DD",f5.2,",",f5.2
4: clr 7
5: for N=0 to 575
6: 720*(N-5)/500)→A
7: 3.5*sin(A))→rN
8: next N
9: dsp "Calculation Complete."
10: for I=0 to 511
11: I+62)→C
12: (I-6)/50)→B
13: wrt 704.1,B,rI
14: wrt 704.2,B,rC
15: next I
16: wrt 704,"DL"}cmd 7,"?"
17: dsp "Done"
18: end
```

Program 1

The symbol used by the 9825A to indicate replacement of a variable is printed as a modified parenthesis with a horizontal center line pointing to the right, and is called a "brace." Its appearance is similar to ") ".

Program number 2, listed below, causes the data from the selected channel to be read from the D14 and stored in an *r* variable in the 9825A. The data can then be printed on an external bus-interfaces printer. Data is in dB.

```
0: "This prog. uses RA,RB,&RV.";
1: "Version 2, 1 May 1980";
2: "The D14 has address 4) the printer address 20.";
3: "Reads 501 points; prints as requested.";
4: dim A$[22],B$[22],AC[5],BC[5]
5: ent "Data from a or b channel?",A$
6: "a"→B$;if A$=B$;1→Q
7: clr 7
8: fmt 1,"RV",f5.2
9: fmt 2,f6.2,f7.2,f10.2,f7.2,f10.2,f7.2,f10.2,f7.2,f10.2,f7.2,z
10: fmt 3,22x,"A CHANNEL LOCATION-DATA"
11: fmt 4,22x,"B CHANNEL LOCATION-DATA"
12: fmt 5,f6.2,f7.2
13: if Q=1;wrt 704,"RA";sto "DATA"
14: wrt 704,"RB"
15: "DATA";for N=0 to 500
16: N/50→I;wrt 704.1,I
17: red 704,rN;next N
18: cli 7
19: ent "Print N points/division",E
20: clr 7;wtb 720,13
21: if Q=1;wrt 720.3;sto "PRINT"
22: wrt 720.4;sto "PRINT"
23: "PRINT";dsp "DATA PRINTING";cli 7;for M=0 to 2*E-1
24: 50/E→I
25: 5*M*I→AC[1];AC[1]+I→AC[2];AC[2]+I→AC[3];AC[3]+I→AC[4];AC[4]+I→AC[5]
26: AC[1]/50→BC[1];AC[2]/50→BC[2];AC[3]/50→BC[3];AC[4]/50→BC[4];AC[5]/50→BC[5]
27: wrt 720,2,BC[1],rAC[1],BC[2],rAC[2],BC[3],rAC[3],BC[4],rAC[4],BC[5],rAC[5]
28: wtb 720,13
```

```
29: next M

30: wrt 720,5,10,r500

31: wtb 720,13,10

32: cli 7

33: dsp

34: end
```

Program 2

The "brace" is the symbol used by the 9825A to indicate replacement of a variable. Its appearance is similar to " } ".

Program number 3, listed below, is similar to program number 2, but uses data from the display memory rather than from the channel plug-in. Data is in divisions.

```
0: "This prog. uses DA,DB,&DV,";

1: "Version 3, 1 Mas 1980";

2: "The D14 has address 4; the printer address 20.";

3: "Reads 501 points; prints as requested.";

4: dim A$[23,B$[23,A[53,B[53

5: ent "Data from a or b channel?",A$

6: "a"→B$;if A$=B$;1→Q

7: clr 7;wrt 704,"DM;DU"

8: dsp "When CRT stable,press continue.";stp

9: fmt 1,"DV",f5.2

10: fmt 2,f6.2,f6.2,f10.2,f6.2,f10.2,f6.2,f10.2,f6.2,f10.2,f6.2,z

11: fmt 3,22x,"A CHANNEL LOCATION-DATA"

12: fmt 4,22x,"B CHANNEL LOCATION-DATA"

13: fmt 5,f6.2,f6.2

14: if Q=1;wrt 704,"DA";sto "DATA"

15: wrt 704,"DB"

16: "DATA";for N=0 to 500

17: N/50→I;wrt 704.1,I
```

```
18: red 704,rN;next N
19: cli 7
20: ent "Print N points/division",E
21: clr 7;wtb 720,13
22: if 0=1;wrt 720.3;sto "PRINT"
23: wrt 720.4;sto "PRINT"
24: "PRINT";dsp "DATA PRINTING";cli 7;for M=0 to 2*E-1
25: 50/E>I
26: 5*M*I>AE1];AE1]+I>AE2];AE2]+I>AE3];AE3]+I>AE4];AE4]+I>AE5]
27: AE1]/50>BE1];AE2]/50>BE2];AE3]/50>BE3];AE4]/50>BE4];AE5]/50>BE5]
28: wrt 720,2,BE1],rAE1],BE2],rAE2],BE3],rAE3],BE4],rAE4],BE5],rAE5]
29: wtb 720,13
30: next M
31: wrt 720,5,10,r500
32: wtb 720,13,10
33: cli 7
34: dsp
35: end
```

Program 3

The "brace" is the symbol used by the 9825A to indicate replacement of a variable. Its appearance is similar to " } ".

Listed below is program 4 which will cause the collection of plug-in data and the storing of the data on tape. The last part of the program reads the tape and writes to the ratio input of the plug-in. If it is desired to store the data in the plug-in memory during calibration, an additional statement is required to invert the sign of the data.

```
0: "The first part of this program records data from the plug-in";
1: "on tape file 0 using the RA or RB and RV commands.";
2: "Tape file 0 must be marked for >5000 bytes.";
3: "The second part writes data from tape file 0 to the IEEE memory";
4: "and ratios it to the plug-in selected during recording.";
```

```
5: "Version 1, 22 April 1980";
6: sto "INSTR"
7: "RECORD";dim A$[23],B$[23]
8: ent "Data from a or b channel?",A$
9: "a"->B$;if A$=B$;1->Q
10: fmt 1,"RV",f6.2
11: clr 704;wrt 704,"RD"
12: if Q=1;wrt 704,"RA";sto "DATA"
13: wrt 704,"RB"
14: "DATA";for N=0 to 500
15: N/50->I;wrt 704.1,I
16: red 704,rN;next N
17: cll 7
18: 0->r501
19: if Q=1;1->r501
20: ref 0,r0,r501
21: dsp r0,r125,r250,r375,r500;wait 4000
22: sto "RESTART"
23: "RATIO";idf 0,r0,r501
24: clr 704;wrt 704,"RD"
25: fmt 2,"RC",f6.2,",",f6.2
26: for N=0 to 500
27: N/50->X;wrt 704.2,X,rN;wait 5
28: next N
29: if r501=1;wrt 704,"RH";sto "LAST"
30: wrt 704,"RJ";sto "LAST"
31: "LAST";cmd 7,"?";sto "RESTART"
32: "INSTR";dsp "Type 'ldk 5' to load fn keys.";wait 5000
33: dsp "Insert blank tape with file 0";wait 3000
```

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