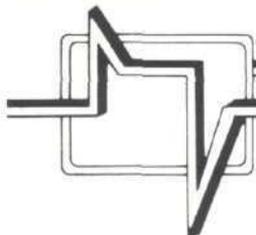
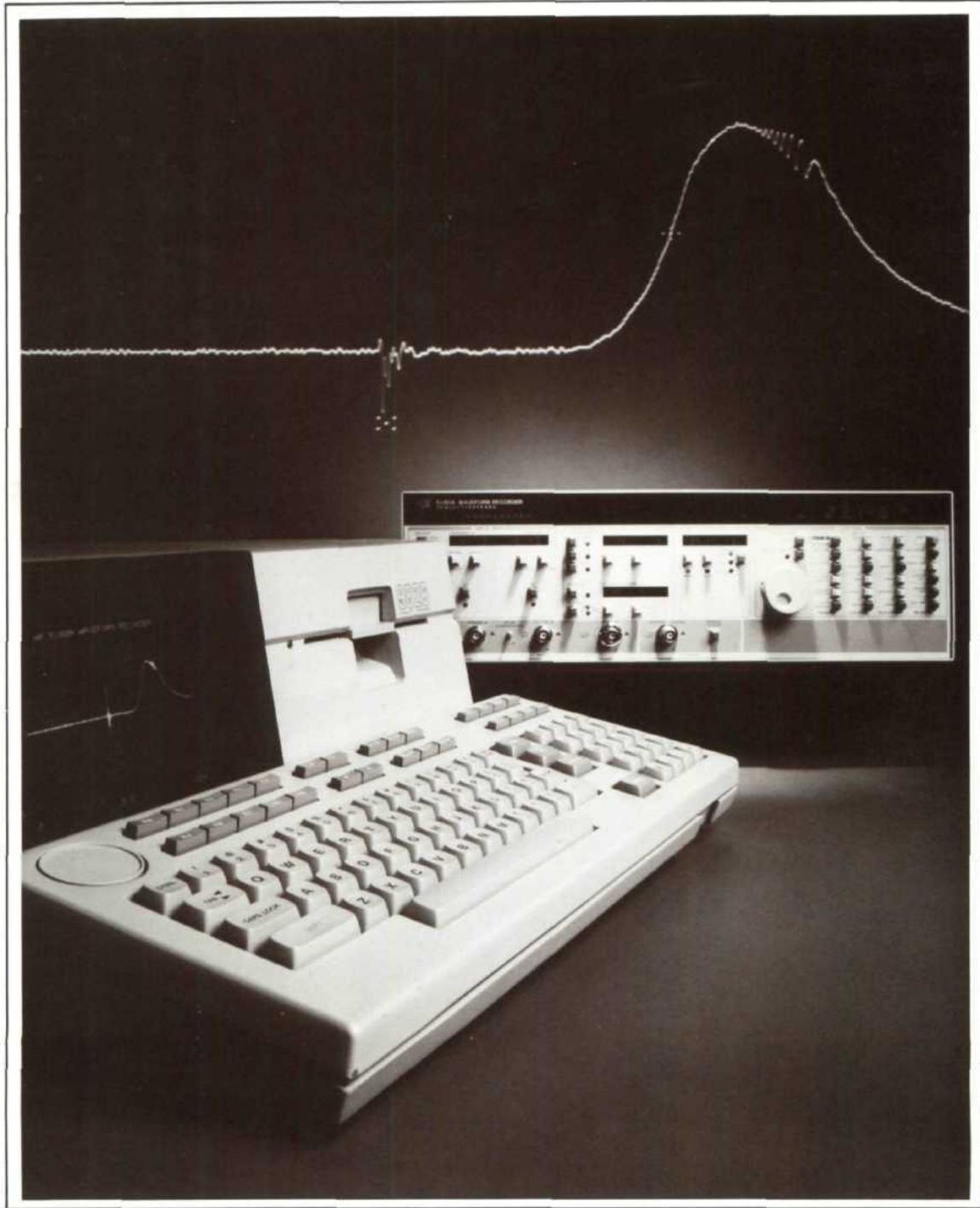


Extending Frequency Range and Increasing Effective Sample Rate on the 5180A Waveform Recorder





Introduction

This note describes a 5180A based system that can be used with **repetitive inputs** to extend the unaliased frequency measurement range beyond 10 MHz (10 MHz is the 5180A's stand-alone unaliased range limit) and provide effective sample rates in excess of 20 MegaSamples/Second (20 MS/S is the maximum sample rate possible on the 5180A). This system enhances 5180A capability in the same way that a sampling oscilloscope enhances oscilloscope capability. Like the sampling scope, the "sampling 5180A" is useful for extending the frequency measurement range and for providing more complete sampling of any repetitive input.

A feature of the 5180A Sampling System is that fast effective digitizing rates are achieved without sacrificing amplitude resolution. Traditionally, to adequately sample higher frequency input signals, waveform recorders with faster maximum digitizing rates have provided the only solution. A drawback of these faster waveform recorders is that they sometimes don't provide sufficient amplitude resolution to obtain useful measurement results. The 5180A Sampling System can, when the input is repetitive, make these measurements with very good resolution in both amplitude and time. An example of the enhancement that this system can provide appears in Figure 1.

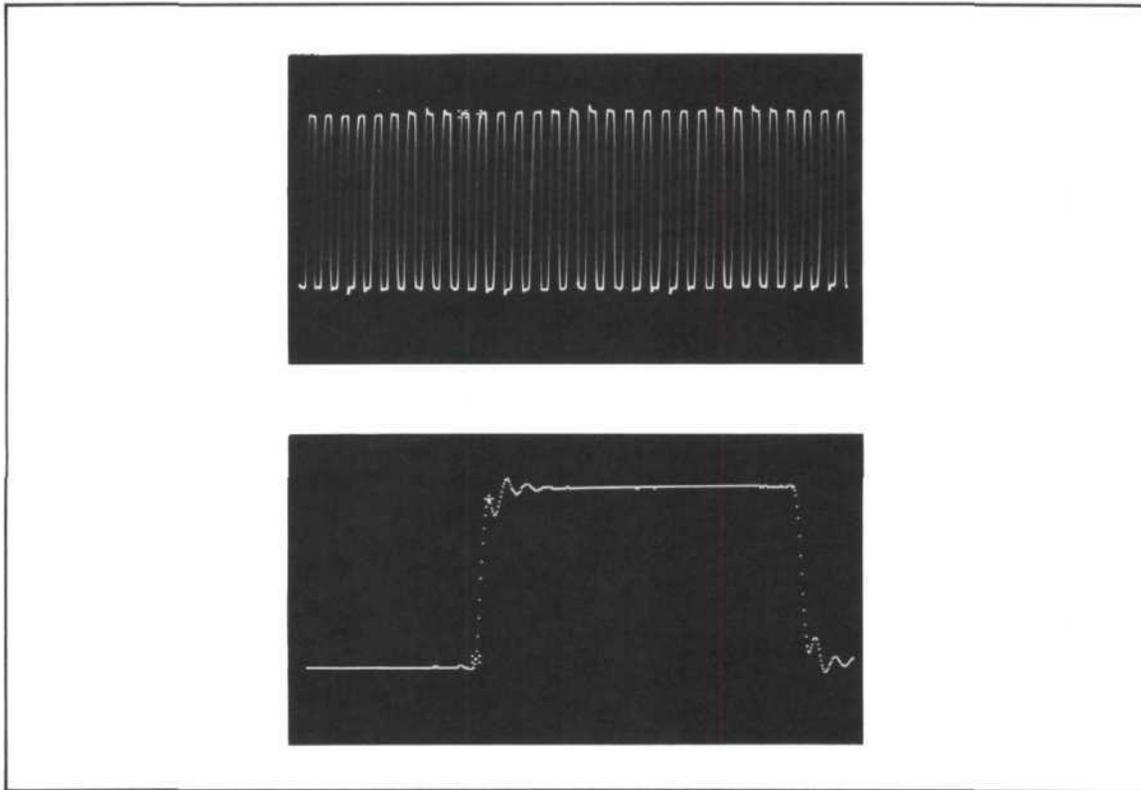


Figure 1. Top display shows pulse train data captured by waveform recorder alone (20 MHz conversion rate). Lower display shows same input captured using system described in this note.

Performance characteristics for the 5180A Sampling System are summarized in the table below:

5180A Input Channel	Maximum Recommended Input Frequency (3 dB Bandwidth)	Maximum Effective Sample Rate
A or B	40 MHz	20 GHz
Auxiliary	70 MHz	

An indication of the quality of the data as a function of the input frequency (dynamic performance) for the system is shown in Figure 9, which summarizes the results of extensive sine wave curvefit testing.*

Highlights of System Operation

In addition to the 5180A Waveform Recorder, the 5180A Sampling System requires a programmable timing generator and an instrument controller. The system implementation described in this note uses a 5359A Time Synthesizer and a 9826 Controller. Figure 2 shows the set-up.

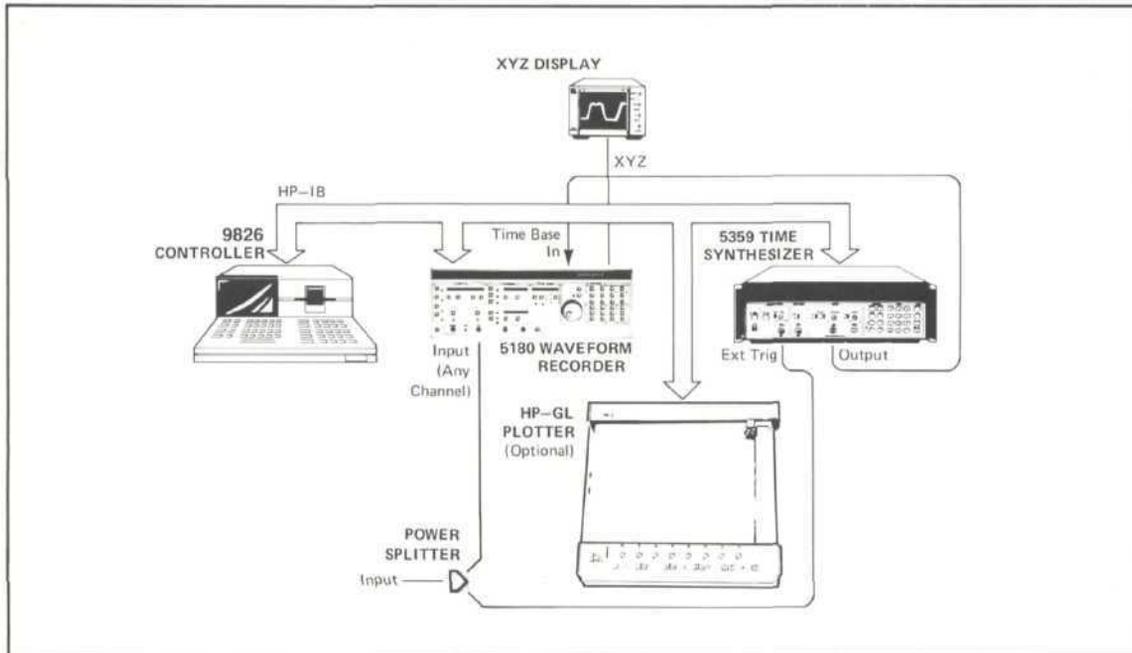


Figure 2. 5180A sampling system.

The measurement technique is similar to that used in a sampling scope – the sample point is walked through the input by successively increasing the delay between the occurrence of an input trigger and the time the input is sampled. As can be seen from Figure 2, the 5359A is externally triggered by the input signal.** The time between occurrence of this trigger and the output of a pulse from the 5359A is precisely controllable (increments as small as 50 picoseconds), so the 5359A provides the variable delay capability. The output pulse from the 5359A is the input that tells the 5180A when to sample the input signal. A detailed description of the system operation appears in the next section.

*The sine wave curvefit test is an ADC (Analog-to-Digital Converter) performance measure used by Hewlett-Packard and other waveform recorder producers to evaluate the overall quality of the analog-to-digital conversion process. This test is particularly meaningful because it incorporates many of the error factors that can degrade ADC performance.

**For repetitive inputs that don't have a uniquely definable trigger within one period of the input waveform, such as phase coherent pulsed RF (no unique trigger is definable because the signal passes through the same level with the same slope many times within one period), another trigger signal must be generated. For example, with phase coherent pulsed RF, the modulating signal could be used as the trigger.

Here's How it Works

When the 5180A Sampling system is collecting data it iterates through a simple procedure that can be described in chronological steps:

- STEP A: The input passes through the external trigger level set on the 5359A Time Synthesizer, thus triggering it.
- STEP B: The amount of delay time that has been programmed into the 5359A elapses.
- STEP C: At the end of the delay time the 5359A generates a pulse.
- STEP D: The output pulse, being the timebase for the 5180A, causes the 5180A to sample the input once.
- STEP E: After the 5359A output pulse has occurred, the 5359A is automatically re-armed and again becomes ready to accept an external trigger.

Steps A-E are repeated as many times as there are data points in the 5180A record (determined by 5180A RECORD LENGTH value).

- STEP F: Once the record has filled, the data is output to the 9826 Controller and the 5359A delay time is increased. Steps A-E are then repeated again.

The process continues until the desired number of measurements have been taken.

- STEP G: The measurement data is processed and the results are written to the 5180A, or may be plotted on the 9826 display.

The 9826 Controller oversees the entire measurement process. This sequence of steps is depicted in Figure 3. Figures 4 and 5 show the signal timing relationships.

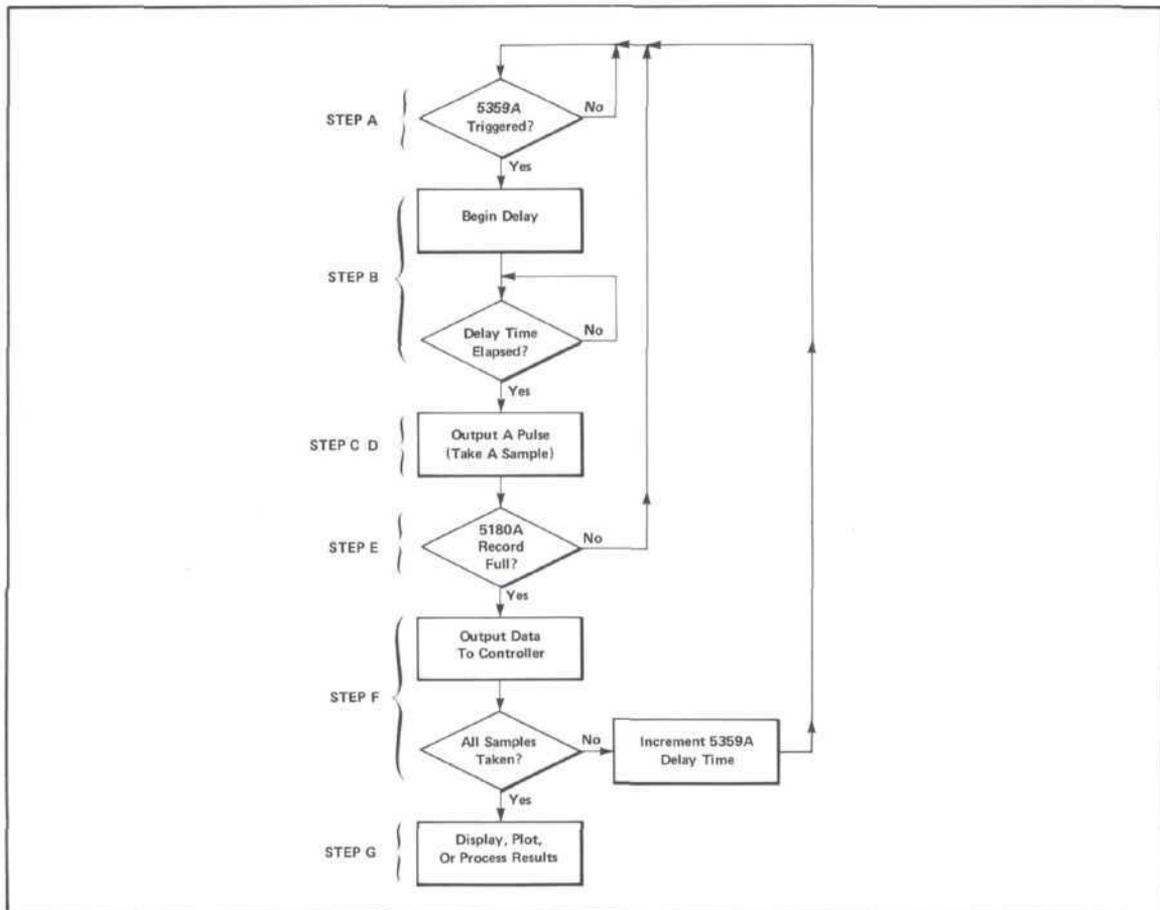


Figure 3. Flow diagram for measurement process.

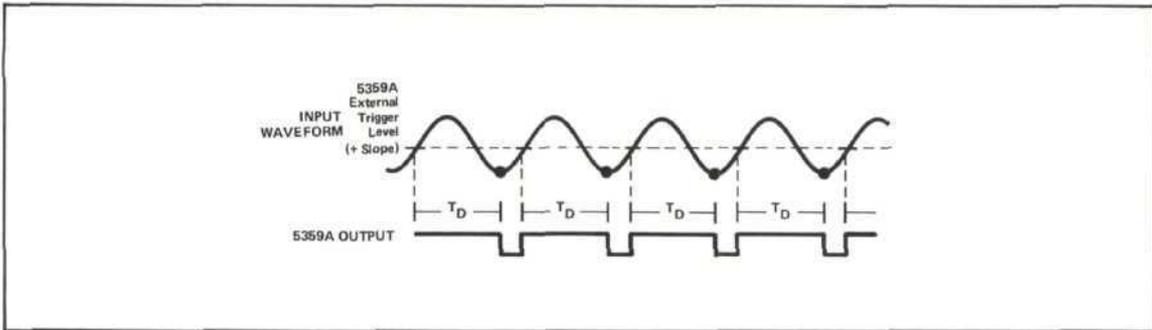


Figure 4. Timing relationships for 5180A sampling system. T_D is 5359A delay time. • indicates the value of the input when the sample occurs.

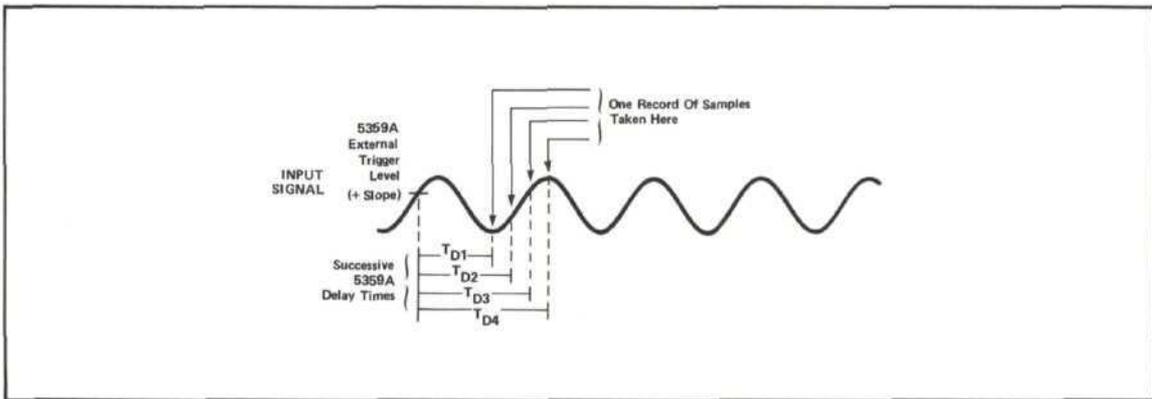


Figure 5. Successive data records are collected at successive time delays for complete sampling of input.

Processing the Data

As each data record is output to the 9826 Controller, the data may be averaged and the average saved or a single data point can be saved. Averaging the data is useful for removing noise (random) components from the input signal. The “smoothing” effect of averaging is illustrated in Figure 6.

Whether the data is averaged or not, the input signal is reconstructed by plotting or displaying the saved data point from each record versus the value of the time delay associated with that record.

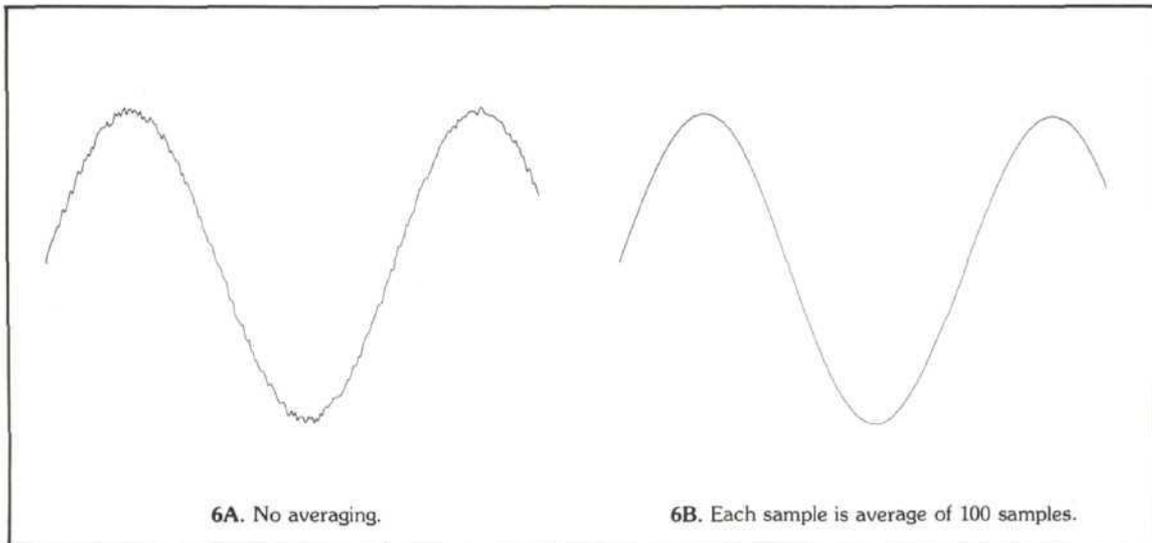


Figure 6. Averaging reduces the effect of random noise.

Putting the System Together

The equipment set-up and required interconnections are shown in Figure 2. A step-by-step procedure for making the 5180A Sampling System operational is provided below:

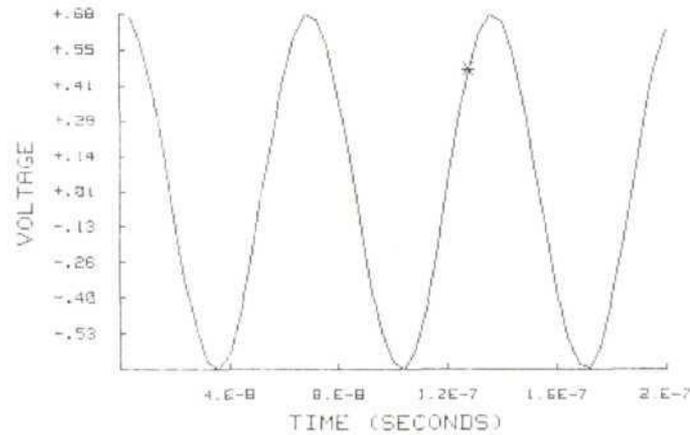
1. Complete the system interconnections according to Figure 2. HP-IB device addresses are: 04 for the 5180A, and 10 for the 5359A.
2. A rotary switch near the 5180A's timebase-in input can be set to sample at various input levels: -1, -.3, 0, or 1.8 volts into 50 ohms. Since the 5359A has flexible output level capability, any of the 5180A's timebase-in threshold levels could be used. The simplest choice is to set the rotary switch for a zero volt threshold (position 3).
3. Preset the 5180A by pressing the SHIFT key followed by the key marked PRESET. Position the rear-panel INT/EXT timebase switch to EXT, and select the AUTO sweep arming mode.
4. Set the 5359A front panel to:
Sync Delay Preset
Polarity Norm and Pos
Offset On
5. On power-up the 5359A outputs a 1 MHz repetitive pulse train. This signal is convenient for establishing that the 5359A output is actually causing the 5180A to sample. Set the output level on the 5359A by pressing DISPLAY LEVELS to bring up the amplitude and offset values on the 5359A display. Adjust the amplitude to about 2 volts with a -1 volt offset. This should cause the output pulse to change from -1 to 1 volt, thus assuring that the 5180A timebase-in threshold level is crossed. If sampling is occurring the input signal will be changing on the XYZ display and the ARM and TRIG annunciators on the 5180A will be flashing. If the 5180A isn't sampling, check and adjust the 5359A output levels.
6. Having verified that the 5359A output is causing the 5180A to sample, the final hardware step is to set the external trigger level on the 5359A. With input signal applied press the DELAY key on the 5359A. The 5359A display will blank, indicating that it's waiting for you to input a delay value. Press 10 (data entry section) followed by ns (units section). This entry specifies that the 5359A will output a pulse 10 nanoseconds after the occurrence of an external trigger (there is some additional fixed delay, but this isn't important). Use the external trigger level adjustment to set an appropriate external trigger level. To verify that an unambiguous trigger level has been chosen, view the captured waveform on the XYZ display. The waveform should be live and essentially a horizontal line. The display represents the data for one sample point of the repetitive input. Since all the data is being taken at the same delay time after the 5359A is externally triggered, you would expect the displayed waveform to be a horizontal line (see Figure 4). If it isn't horizontal, or if the 5180A isn't sampling, adjust the external trigger level on the 5359A.

Once the previous six steps have been successfully completed the system hardware is operational. The system software remains to be loaded into the 9826 Controller. The system software, with documentation and a variable list, is presented in the appendix.

Some of the key features of the 5180A Sampling System software are:

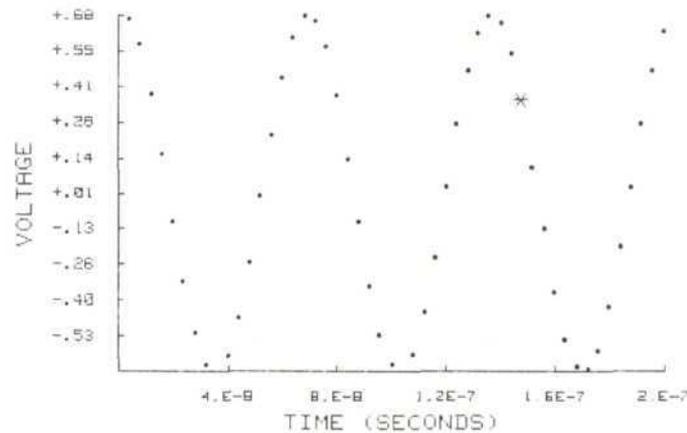
- Softkeys are used to control all system functions.
- Using the softkeys the following parameters can be controlled by the user:
 - 1) Effective sample rate
 - 2) Number of samples per measurement
 - 3) Extent of averaging per sample point
 - 4) 5180A record location for storing measurement results
 - 5) High-speed or Normal acquisition mode. The normal acquisition mode uses the measurement procedure of Figure 3. The high-speed mode employs a slightly different procedure, using the 5180A's AUTO ADVANCE feature to sample up to 32 points before any data is output from the 5180A.

- Once the data is collected and processed in the 9826 it is automatically written back into the 5180A. The 5180A display controls can then be used to examine the captured waveform. The amplitude levels are accurate but no time per sample information is available from this display.
- The PLOT softkey displays the measurement result on the 9826 display. An advantage of this display over the data as stored and displayed by the 5180A is that the scaling is optimized on the 9826 display for the actual amplitude and time range of the measurement. A dot/line mode similar to this feature on the 5180A is provided on the 9826 display. Also, a cursor may be enabled for simultaneous time and voltage readout of the data on the 9826 display. These readouts appear in the softkey menu area. Positioning of the cursor is controlled via the 9826 control knob. Illustrations of the 9826 display plot appear below.



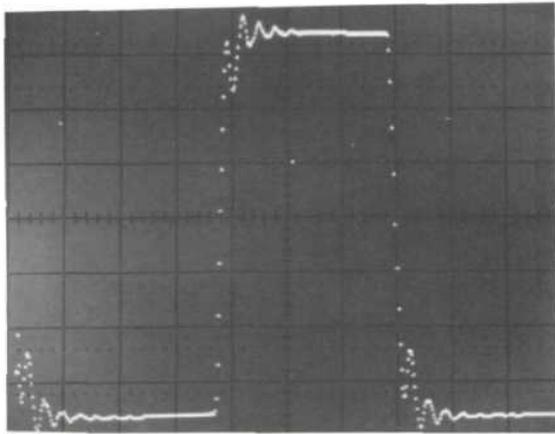
EXIT	TIME	VOLTAGE	
PLOT	1.36E-7	.49	

7A. 9826 plot using LINE mode.



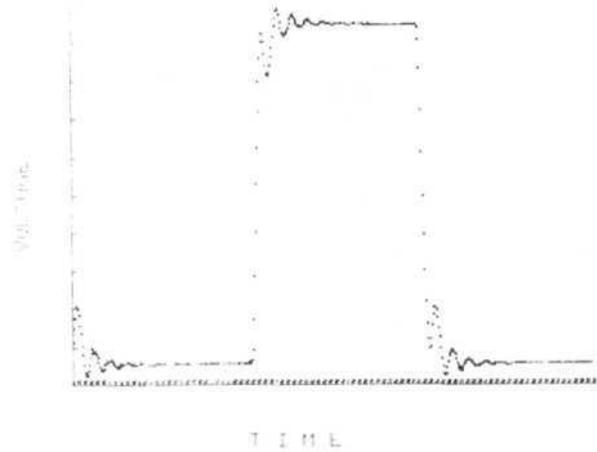
EXIT	TIME	VOLTAGE	
PLOT	1.48E-7	.406	

7B. 9826 plot using DOT mode.

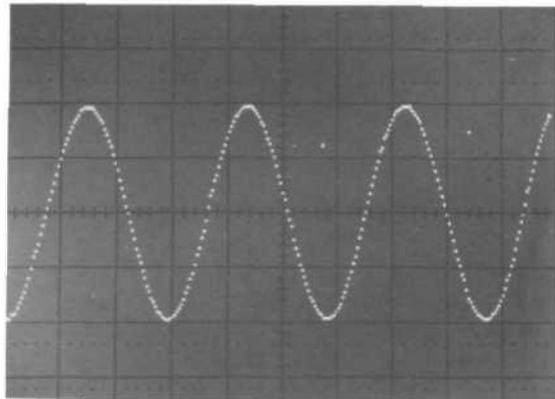


XYZ DISPLAY

8A. Square wave output captured using sampling technique. Effective sample rate is 667 MHz. (1.5 nanoseconds/sample),

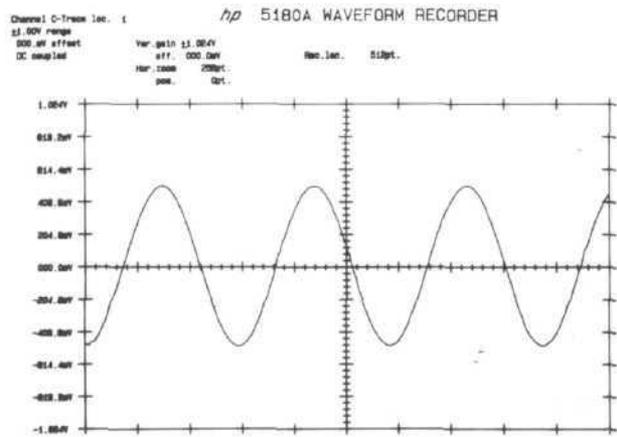


PLOT GENERATED BY 9826 CONTROLLER

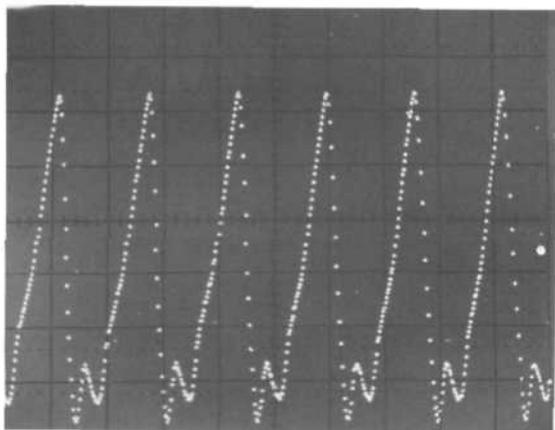


XYZ DISPLAY

8B. 53.64 MHz sine wave captured using sampling technique. Effective sample rate is 4 GHz. (250 picoseconds/sample).

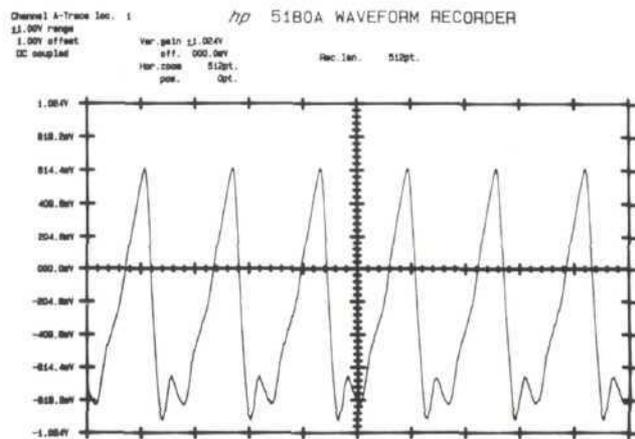


5180A GENERATED PLOT



XYZ DISPLAY

8C. Output captured using sampling technique. Effective sample rate is 1 GHz. (1 nanosecond/sample).



5180A GENERATED PLOT

Figure 8. Examples of system output.

Measurement Considerations

An indication of typical dynamic performance for the 5180A Sampling System is shown in Figure 9, which plots input frequency versus effective bits (an excellent description of “effective bits” and the test that determines this result appears in 5180A Product Note 5180-2).

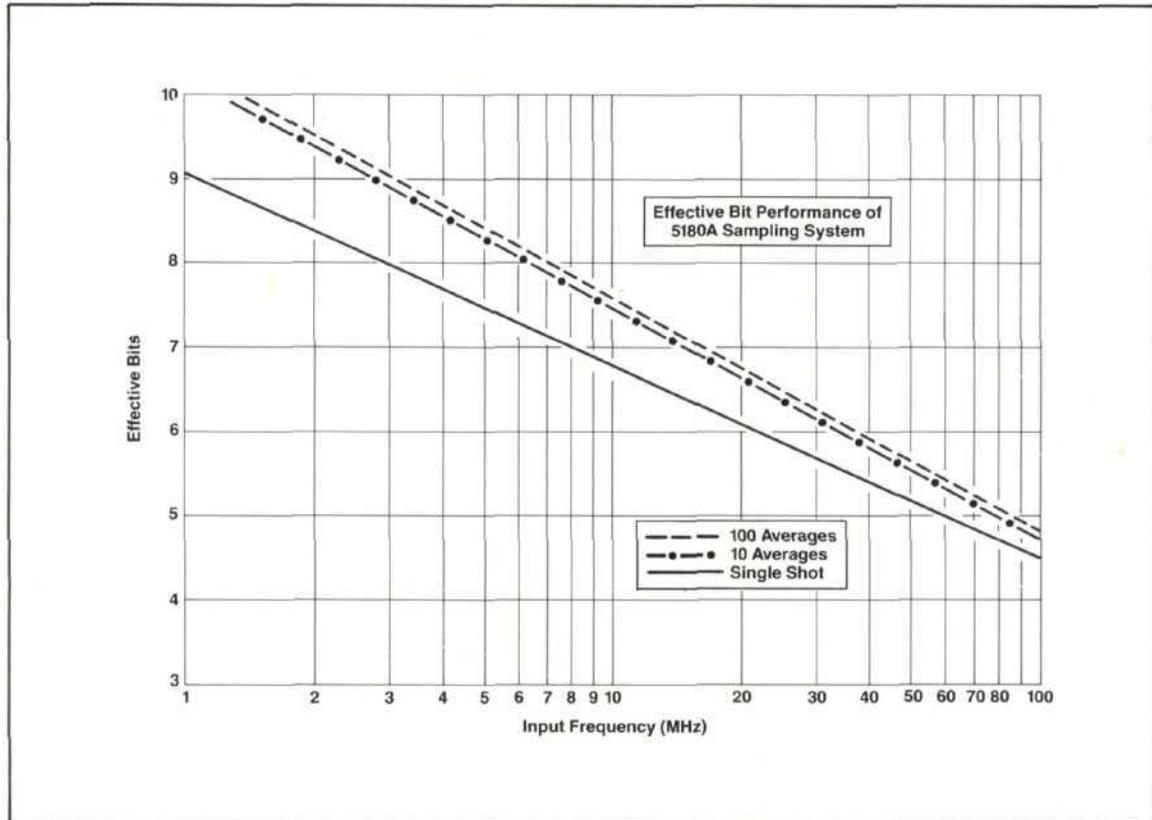


Figure 9. Dynamic Performance data for 5180A Sampling System. Effective sample rate was 500 MHz.

Other important considerations regarding the performance of the 5180A Sampling System are described below.

1. 5180A INPUT BANDWIDTH

The input bandwidths of the 5180A (see table, page 2) impose an upper limit on the frequency extension range of the system. Since the 5180A front-end can be modeled as a single-pole low pass filter (for any of the input channels), data can be collected beyond the 3 dB point, but attenuation and phase-shifting will affect the data according to Figures 10 and 11.

2. 5359A EXTERNAL TRIGGER BANDWIDTH

Since the 5359A Time Synthesizer is externally triggered by the input signal in most implementations of the system (for an exception see the footnote on page 4), the external trigger bandwidth can impose limitations. Measurements taken to evaluate this limitation indicate that the 5359A will trigger reliably for inputs up to 100 MHz.

3. 5359A MINIMUM DELAY STEP SIZE

The 5359A delay step is the effective time per sample of the 5180A Sampling System. Since the minimum delay step size on the 5359A is 50 picoseconds, the maximum effective sample rate is $1/50$ picoseconds = 20 GHz. NOTE: This doesn't mean, of course, that inputs in the GHz range can be captured using the 5180A Sampling System (see the previous two points for the reasons). It does mean that lower frequency, repetitive inputs can be sampled at a 20 GHz rate.

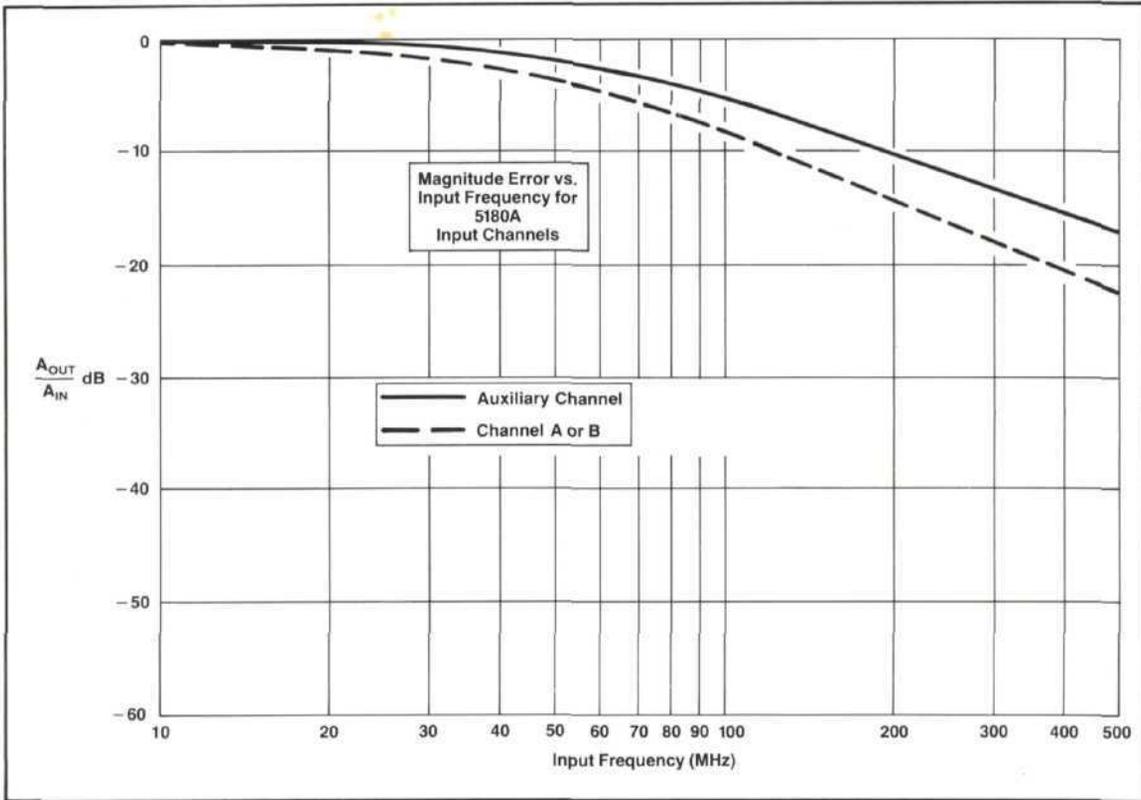


Figure 10. A_{OUT} : Output magnitude (value measured in 5180A) A_{IN} : Input magnitude

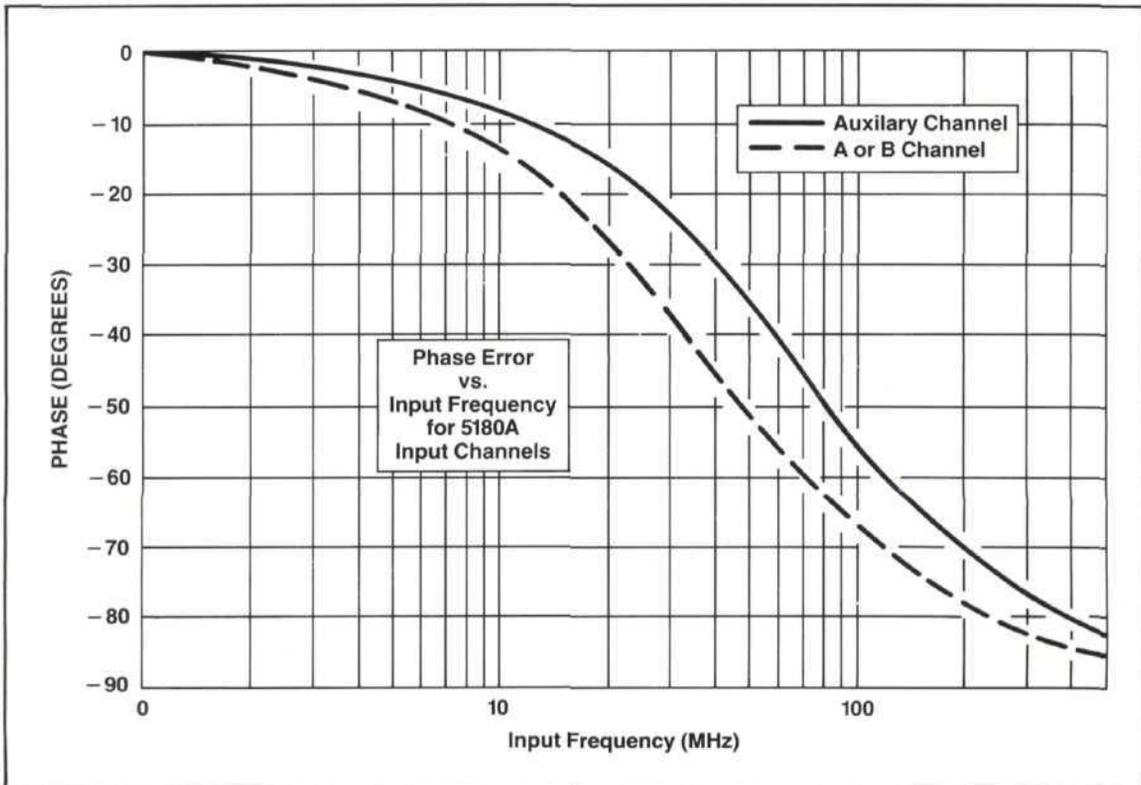


Figure 11.

4. 5359A OUTPUT STABILITY

Since the 5359A controls the sampling of the 5180A Waveform Recorder, the output jitter of the 5359A is actually the aperture uncertainty of the 5180A Sampling System. The effect of aperture uncertainty is a factor in the effective bit measurement. 5359A output jitter (specified at 100 picoseconds TYPICAL) is probably the main cause of performance degradation with increasing input frequency.

5. SYSTEM ACQUISITION TIME

Since the measurement technique requires multiple passes through the input signal before the data can be processed, the time to acquire the signal is an important measurement consideration. The acquisition time is the time between collecting the first data point in the first data record and the last data point in the last record. Acquisition times for the 5180A Sampling System are shown in Figure 12.

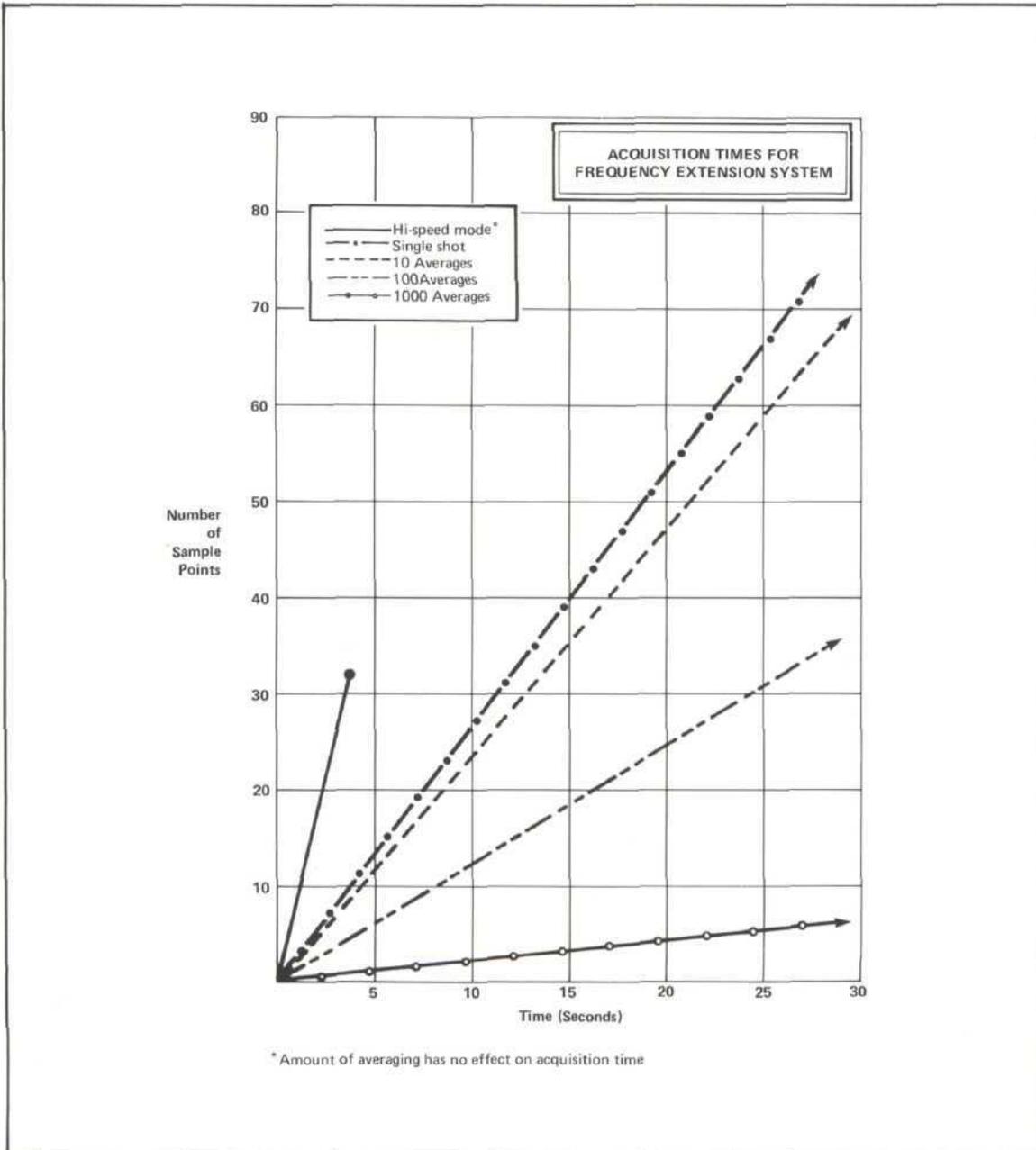


Figure 12.

Appendix : 5180A Sampling System Software

The 5180A Sampling System is controlled by the system software listed in this appendix. The program is written for BASIC as implemented in the 9826A controller. The structure of the software should be evident from the variable list and documentation included alongside the program listing. To operate the system software is simple: after pressing RUN all of the user options appear in the softkey menu. To modify a parameter, press the appropriate softkey, respond to the prompt, and press CONTINUE on the 9826.

The DISPLAY, PLOT, and CURSOR subroutines are useful as general purpose subroutines and could be used with the 5180A in any application to bring the data up on the 9826 display. Although not implemented in this listing, it should be possible to modify the HISPEED subroutine to sample more than 32 points. This could be accomplished using a DMA data transfer from the 5180A to the 9826 following each filling of the 5180A memory. The transferred data could be held in the controller while another series of 32 measurements is taken. This process could be repeated many times (the 9826 has plenty of memory to hold the unprocessed data) and then finally, all the data in the 9826 could be processed to obtain the measurement result.

Variable List and Definitions : in Order of Appearance in the Program

C\$[*]	: used to store 5180A teach strings
Code(*)	: Data array (if memory limitations become important, Code(*) could be ALLOCATED (see 9826 manual) a size of the variable "Length", instead of being dimensioned).
Location	: 5180A record location where processed data will be stored
Average	: Number of averages per sample point
R	: Effective sample rate
Samples	: Number of samples per measurement
Length	: 5180A record length
Flag	: Indicates high-speed or normal measurement mode
C	: Temporary data storage
Stay	: Flag to allow new display plot on 9826
Channel	: 5180A input channel (1=A, 2=B, 4=auxiliary)
Range	: 5180A input range
Offset	: 5180A offset
Minimum	: Minimum Code(*)
Maximum	: Maximum Code(*)
V _{max}	: Maximum voltage of data
V _{min}	: Minimum voltage of data
Connect	: Flag identifying dot or line mode for 9826 display plot
Mov	: Variable indicating cursor position for 9826 display plot
Old	: Previous value of Mov
Left	: Indicates Sample range over which data must be re-plotted on 9826 display following a cursor erase

```

10      !
20      !5180A SAMPLING SYSTEM
30      !
40 Main:      !
50      DIM ,C$( 300) ,Code(16384)
60      A$="NORMAL"
70      Length=512
80      Location=1
90      Average=1
100     GRAPHICS OFF
110     ASSIGN @Hp5180 TO 704
120     ASSIGN @Hp5359 TO 710
130     ON KEY 0 LABEL "TIME/PT" GOSUB Sample
140     ON KEY 2 LABEL "SAMP="&VAL$(Samples) GOSUB Number
150     ON KEY 3 LABEL A$ GOSUB Mode
160     ON KEY 4 LABEL "MEASURE" GOSUB Measure
170     ON KEY 5 LABEL VAL$(R) GOSUB Sample
180     ON KEY 7 LABEL "REC="&VAL$(Location) GOSUB Record
190     ON KEY 8 LABEL "AVE="&VAL$(Average) GOSUB Average
200     ON KEY 9 LABEL "PLOT" GOTO 1110
210     DISP "SELECT DESIRED FUNCTION"
220     OFF KNO3
230     GOTO 130
240     !
250 Sample:  !
260     INPUT "ENTER SAMPLE RATE" ,R
270     OUTPUT @Hp5359;"DSS" ,R
280     RETURN
290     !
300 Number:  !
310     INPUT "ENTER NUMBER OF SAMPLES" ,Samples
320     RETURN
330     !
340 Average:  !
350     INPUT "ENTER AVERAGES PER SAMPLE" ,Average
360     FOR I=9 TO 14
370         IF Average<2^I THEN GOTO 390
380     NEXT I
390     Length=2^I
400     RETURN
410     !
420 Mode:  !
430     IF Flag=0 THEN
440         A$="HI-SPEED"
450         Flag=1
460     ELSE
470         A$="NORMAL"
480         Flag=0
490     END IF
500     RETURN
510     !
520 Measure:  !
530     DISP "MEASUREMENT IN PROGRESS"
540     OUTPUT @Hp5359;"DOE-9,N20E-9"
550     OUTPUT @Hp5180;"TEL,SA3,SEL,PP5,LE," ,Length
560     FOR I=1 TO Samples
570         Code(I)=0
580     NEXT I

```

Initialize

Assign I/O Path name for 5180A and 5359A

Define Soft Keys

Program Effective Sample Rate

Determine number of samples

Determine extent of averaging and compute appropriate 5180A record length

Hi-speed or Normal Measurement Mode

set-up 5359A

set-up 5180A

```

590 IF Flag=1 THEN GOTO Hispeed
600 OUTPUT @Hp5180;"LO," ,Location
610 FOR I=1 TO Samples
620   OUTPUT @Hp5180;"MT"
630   IF BIT(SPOLL(704),3)=0 THEN GOTO 630
640   OUTPUT @Hp5180;"OS," ,Location
650   OUTPUT @Hp5180;0,Average
660     FOR J=1 TO Average
670       ENTER @Hp5180;C
680       Code(I)=Code(I)+C
690     NEXT J
700   Code(I)=Code(I)/Average
710   OUTPUT @Hp5359;"DSU"
720 NEXT I
730 GOSUB Display
740 LOCAL @Hp5180
750 RETURN
760 !
770 Hispeed: !
780 OUTPUT @Hp5180;"AD0,LO1,AA1"
790 OUTPUT @Hp5180;"SA3"
800 Samples=(16384/INT(Length))
810 DISP "MEASUREMENT IN PROGRESS"
820 FOR I=1 TO Samples
830   OUTPUT @Hp5180;"MT"
840   IF BIT(SPOLL(704),3)=0 THEN GOTO 840
850   OUTPUT @Hp5359;"DSU"
860 NEXT I
870 FOR I=1 TO Samples
880   DISP "ACQUISITION COMPLETE"
890   OUTPUT @Hp5180;"OS," ,I
900   OUTPUT @Hp5180;0,Average
910     FOR J=1 TO Average
920       ENTER @Hp5180;C
930       Code(I)=Code(I)+C
940     NEXT J
950   Code(I)=Code(I)/Average
960 NEXT I
970 GOTO 730
980 !
990 Display: !
1000 FOR I=Samples+1 TO Length
1010   IF Samples=Length THEN GOTO 1040
1020   Code(I)=512
1030 NEXT I
1040 OUTPUT @Hp5180;"JB," ,Location
1050 FOR I=1 TO Length
1060   OUTPUT @Hp5180;Code(I)
1070 NEXT I
1080 OUTPUT @Hp5180;"TL," ,Location
1090 RETURN
1100 !
1110 Plot: !
1120 Stay=0
1130 DISP ""
1140 OFF KEY
1150 OFF KNOB
1160 ON KEY 0 LABEL "EXIT" GOTO 100
1170 ON KEY 2 LABEL "CURSOR" GOTO 1890

```

Trigger 5180A
 wait for 5180A record to fill
 set-up 5180A for selective ASCII output
 Averaging Loop
 increase the delay time
 Main Measurement Loop
 set-up 5180, use Auto-Advance mode
 determine number of available 5180A records
 High Speed Measurement Loop
 Data Processing Loop
 Fill all extra points in 5180A record with a baseline
 set-up 5180A to accept processed data
 write data into 5180
 Redefine Soft Keys

```

1180 ON KEY 4 LABEL "DOT" GOTO 1810
1190 ON KEY 5 LABEL "PLOT" GOTO 100
1200 ON KEY 9 LABEL "LINE" GOTO 1850
1210 IF Stay=1 THEN GOTO 1210
1220 GCLEAR
1230 GRAPHICS ON
1240 VIEWPORT 20,125,20,90
1250 WINDOW 0,100,0,100
1260 CLIP ON
1270 AXES 20,10,0,0
1280 CLIP OFF
1290 CSIZE 5
1300 MOVE 50,-15
1310 LABEL "TIME (SECONDS)"
1320 DEG
1330 LDIR 90
1340 MOVE -17,50
1350 LABEL "VOLTAGE"
1360 LDIR 0
1370 CSIZE 3.4
1380 LORG 5
1390 OUTPUT @Hp5180;"OI," ,Location
1400 ENTER @Hp5180;C$
1410 FOR I=1 TO LEN(C$)
1420     IF C$(I,I)=" " THEN C$(I,I)="+"
1430 NEXT I
1440 Channel=VAL(C$(POS(C$,"ch")+2|0))
1450 IF Channel=1 THEN B$="a"
1460 IF Channel=2 THEN B$="b"
1470 Range=VAL(C$(POS(C$,B$&"r")+2|0))
1480 Offset=VAL(C$(POS(C$,B$&"o")+2|0))
1490 IF Channel=4 THEN Range=1
1500 IF Channel=4 THEN Offset=0
1510 Minimum=1023
1520 Maximum=0
1530 FOR I=1 TO Samples
1540     IF Code(I)>Maximum THEN Maximum=Code(I)
1550     IF Code(I)<Minimum THEN Minimum=Code(I)
1560 NEXT I
1570 Vmax=Range*(Maximum-512)*.002-Offset
1580 Vmin=Range*(Minimum-512)*.002-Offset
1590 WINDOW 0,R*Samples,Vmin,Vmax
1600 FOR I=1 TO 10
1610     MOVE -.1*R*Samples,Vmin+((Vmax-Vmin)*I/10)
1620     LABEL USING "SDD.DD";Vmin+((Vmax-Vmin)*I/10)
1630 NEXT I
1640 FOR I=1 TO 5
1650     MOVE R*Samples*I/5,Vmin-.07*(Vmax-Vmin)
1660     LABEL R*Samples*I/5
1670 NEXT I
1680 FOR I=1 TO Samples
1690     IF Connect=1 AND I>1 THEN GOTO 1710
1700     MOVE I*R,Range*(Code(I)-512)*.002-Offset
1710     DRAW I*R,Range*(Code(I)-512)*.002-Offset
1720 NEXT I
1730 Stay=1
1740 GOTO 1130

```

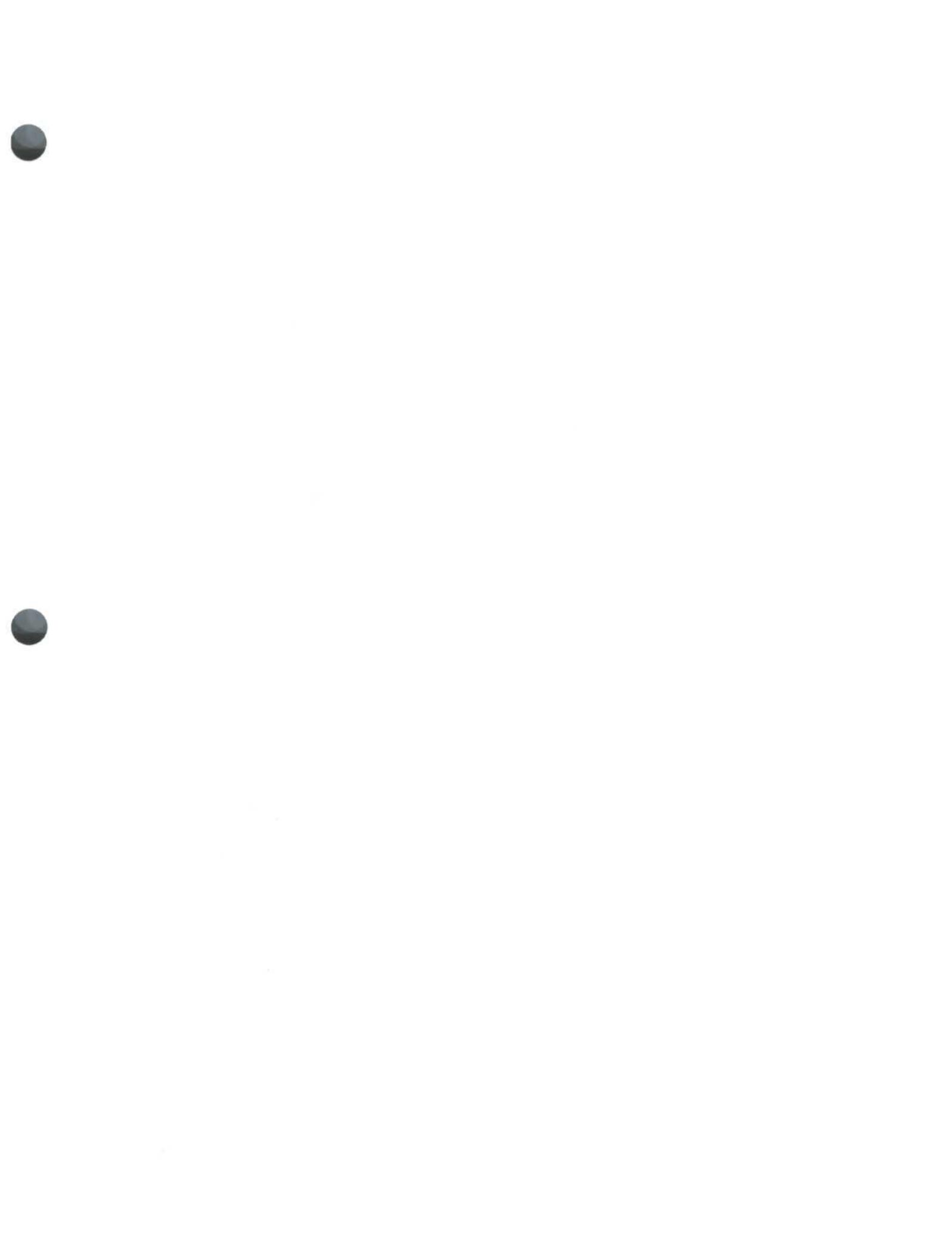
Redefine Soft Keys
 get axes and title on 9826 display
 output and read input amplifier teach string from 5180A
 Determine 5180A input channel, range, and offset
 Find data minimum and maximum
 convert 5180A offset binary code to true voltage value
 label voltage axis values
 label time axis values
 plot the data

```

1750 !
1760 Record: !
1770 INPUT "ENTER RECORD LOCATION",Location ] Determine 5180A record
1780 RETURN ] location for data storage
1790 !
1800 Dot: !
1810 Connect=0 ] Don't connect the data points
1820 GOTO 1220 ]
1830 !
1840 Connect: ! ]
1850 Connect=1 ] Connect the data points
1860 GOTO 1220 ]
1870 !
1880 Cursor: !
1890 Mov=INT(Samples/2) ]
1900 Old=Mov ] Initialize
1910 CLIP OFF ] Cursor
1920 CSIZE 6 ] Parameters
1930 GOTO 2040 ]
1940 ON KNOB .04,15 GOTO 1960 ] wait for 9826 control
1950 GOTO 1950 ] knob to turn
1960 OFF KNOB
1970 Mov=(KNOBX+Mov) ]
1980 IF Mov>Samples THEN Mov=Samples ] determine new
1990 IF Mov<1 THEN Mov=1 ] cursor position
2000 IF Old=Mov THEN GOTO 1940 ]
2010 PEN -1 ]
2020 MOVE Old*R,Range*(Code(Old)-512)*.002-Offset ] erase old cursor
2030 LABEL "*" ]
2040 PEN 1 ]
2050 Left=INT(Samples/52.5) ]
2060 IF Left=0 THEN Left=1 ]
2070 FOR I=-Left TO Left ]
2080 IF Old+I<1 THEN GOTO 2130 ]
2090 IF Old+I>Samples THEN GOTO 2130 ]
2100 IF Connect=1 AND (I>-Left AND Old+I<>1) THEN GOTO 2120 ] Re-plot data
2110 MOVE (I+Old)*R,Range*(Code(I+Old)-512)*.002-Offset ] destroyed
2120 DRAW (I+Old)*R,Range*(Code(I+Old)-512)*.002-Offset ] by cursor
2130 NEXT I ] erase
2140 MOVE Old*R,Range*(Code(Old)-512)*.002-Offset ]
2150 DRAW Old*R,Range*(Code(Old)-512)*.002-Offset ]
2160 MOVE Mov*R,Range*(Code(Mov)-512)*.002-Offset ]
2170 ON KEY 2 LABEL " TIME" GOTO 2170 ] Put cursor information
2180 ON KEY 3 LABEL "VOLTAGE" GOTO 2180 ] in Soft Key label area
2190 ON KEY 7 LABEL VAL$(Mov*R) GOSUB Return ]
2200 ON KEY 8 LABEL VAL$(Range*(Code(Mov)-512)*.002-Offset) GOSUB Return ]
2210 LABEL "*" ] draw the cursor
2220 Old=Mov ] save cursor position
2230 GOTO 1940 ]
2240 Return: RETURN ]
2250 END ]

```







For more information, call your local HP Sales Office or nearest Regional Office: **Eastern** (201) 265-5000; **Midwestern** (312) 255-9800; **Southern** (404) 955-1500; **Western** (213) 970-7500; **Canadian** (416) 678-9430. Ask the operator for instrument sales. Or write Hewlett-Packard, 1501 Page Mill Road, Palo Alto, CA 94304. In Europe: Hewlett-Packard S.A., 7, rue du Bois-du-Lan, P.O. Box, CH 1217 Meyrin 2, Geneva, Switzerland. In Japan: Yokogawa-Hewlett-Packard Ltd., 29-21, Takaido-Higashi 3-chome, Suginami-ku, Tokyo 168.

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