

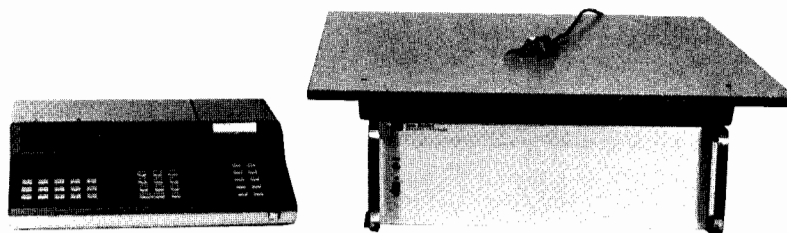
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Hewlett-Packard 9815A Calculator 98134A Option 064 Interface Digitizer Operating Note





HP 98134A Option 064 Interface



HP 9815A Calculator and HP 9864A Digitizer

HEWLETT-PACKARD CALCULATOR PRODUCTS DIVISION

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1

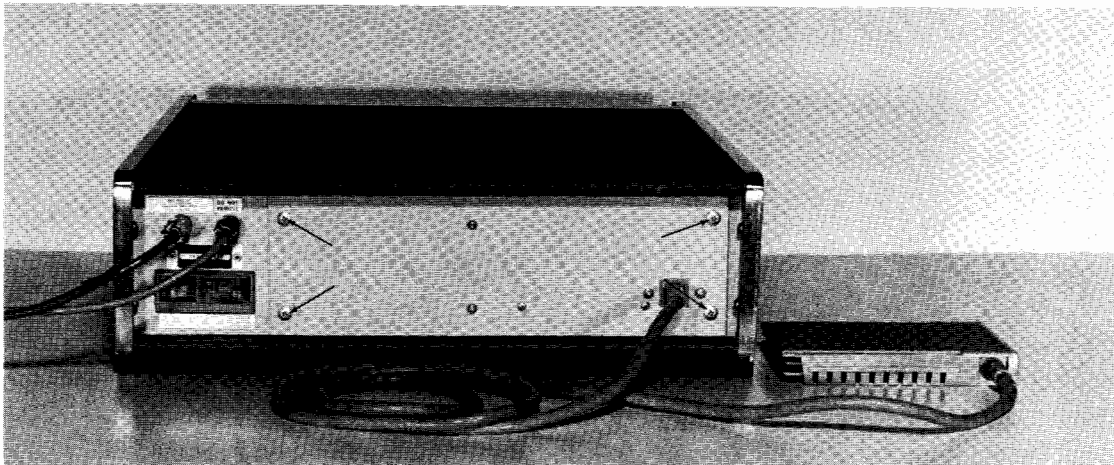
Installation

The HP 98134A Option 064 interfaces an HP 9864A Digitizer to an HP 9815A Calculator. The following sections describe the specific General I/O instructions used to input data from the digitizer. For complete information concerning interface operation and service, refer to the General I/O Operating and Service Manual, HP Part No. 98134-90000.

Connecting the System

You should be familiar with the mechanical operation of the digitizer and its installation requirements before continuing. For information concerning power requirements, grounding assembly procedure, maintenance, etc., refer to the HP9864A Digitizer Peripheral Manual (HP Part No. 09864-90000).

The HP 9864A Option 015 Digitizer is equipped with an HP 98134A General I/O Interface. If your digitizer is equipped with another interface option, you must replace the interface with an HP 98134A Option 064 Interface.



Interface Panel Retaining Screws

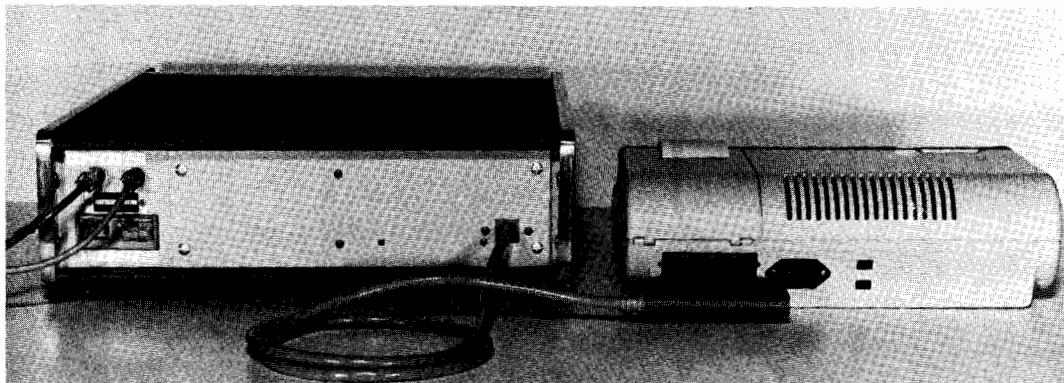
The digitizer must be unplugged when replacing an interface panel. To remove the panel, turn the four retaining screws (shown above) counterclockwise until they release; then remove the panel.

To replace an interface panel, align the retaining screws with their holes, press the panel into place and turn the retaining screws clockwise until they lock in place.

2 Installation

The calculator must be equipped with option 002, two channel I/O, which provides the calculator with the interface connectors and internal I/O compatibility.

The calculator-digitizer system will function properly only if the interface is connected with the calculator switched off. If you accidentally connect the interface with the calculator on, you must switch the calculator off and then on again.



Connecting the Interface

With the calculator switched off, connect the interface to the calculator as shown above. You can connect the interface to either I/O channel in the back of the calculator.

Select Code

The General I/O Interface is preset at the factory to select code 2. Operating two interfaces together requires that each be set to a different select code. If two interfaces set to the same select code are connected to the calculator, the error message "SELECT CODE ERR" will result. Refer to Section 1 of the General I/O Operating and Service Manual for the procedure used to change select codes.

2

Operation



This chapter contains two procedures to check the performance of the HP 9864A Digitizer and the HP 98134A General I/O Interface. The first procedure is used to ensure that the digitizer and the interface are fully operational. The second procedure is used to verify the accuracy of the digitizer.

If, after successfully performing both procedures, you suspect that your digitizer is not operating properly, contact the nearest HP Sales and Service Office for assistance; office locations are listed in Section 3 of the General I/O Operating Service Manual.

During the accuracy check, you may find it helpful to use a magnifying glass to aid in positioning the cross-hairs of the cursor. However, it is possible to achieve satisfactory results without the aid of a magnifying glass.

NOTE

The markings on your digitizer platen may not correspond to those shown in this manual; however, this change does not alter digitizer operation or accuracy.

Equipment Required

The procedures require the following equipment:

1. One HP 9815A Calculator, and one HP 98134A Option 064 General I/O Interface.
2. One HP 9864A Digitizer:
3. One Sample Data Overlay (HP Part No. 09107-90002). A Sample Data Overlay is supplied with the digitizer.
4. One straight-edge, at least 6 inches long.
5. One sheet of paper, 8½ × 11 inches.
6. A pencil or pen.
7. A roll of tape (preferably masking tape).
8. One shim, made of non-magnetic material. The shim should be .025 inches thick, and approximately 3 × 5 inches in its other dimensions. If such a shim is not available, a substitute can be made by stacking four 3 × 5 inch index cards.
9. A magnifying glass (optional).

Function Check

The procedure given in this section verifies digitizer operation, with the exception of accuracy. Since this procedure is long and perhaps tedious, it is recommended that you read the entire procedure before attempting to perform it. Your success is assured only if you carefully follow the directions at each step.

NOTE

The preceding section should be read before continuing, to insure that the calculator and digitizer are properly connected.

1. Connect the calculator and the digitizer to the AC power source. The General I/O Interface should be connected to both the calculator and the digitizer.
2. Referring to Figure 1, place a sheet of $8\frac{1}{2} \times 11$ inch paper on the lower-left hand corner of the digitizing area. Attach the sheet of paper with tape. (The actual position of the paper is not critical.) Using a straight-edge and a pencil, draw a diagonal line on the paper; then label that line as shown in Figure 1.

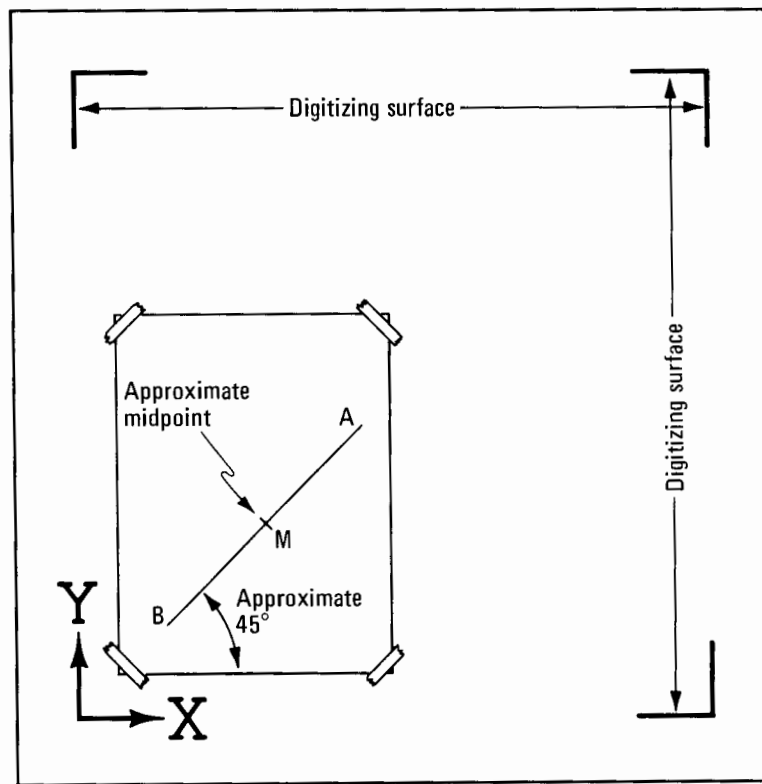




Figure 1. Preparations for the Function Check

3. Switch the calculator on. Insert the Utility and Test Cartridge (HP Part Number 09815-10004) into the tape drive. To load the test program from file – 18:

Press  18  


4. When the tape drive halts:

Press  

Initial printout

```
HP9864A
DIGITIZER
TEST PROGRAM
```


For the first part of this test, enter 1 and

press  .

```
COORDINATE TO BE
DISPLAYED: ENTER
1 FOR X; 0 FOR Y
```

If you want the digitizer to beep after each point is digitized, enter 1. If you don't want a beep, enter 0.

```
BEEP? ENTER:
1=YES, 0=NO
```

Press 

5. Switch the digitizer on. The LINE switch should light and you should hear a beep lasting approximately three-quarters of a second. You should also be able to hear the fan in the digitizer.

NOTE

From this point until the end of this procedure, move the cursor only as directed. When directed to move the cursor from one point to another, do so by sliding the cursor; do not lift the cursor from the digitizing surface unless specifically instructed to do so. Also, do not slide the cursor outside the digitizing area (limits are marked on the platen) unless instructed to do so.

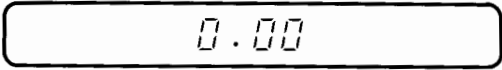
Data Entry Check

6. Place the cursor on the paper which was taped to the digitizing surface. Position the cross-hairs approximately over point M.

NOTE

The controls **S** , **C** , **H** , and **O** are located on the cursor.

7. While being careful not to move the cursor, press **O** . Do not move the cursor. The (red) sample light on the cursor should light, if it was off. Prior to pressing **O** the sample light may have been on or off.
8. Still being very careful not to move the cursor, press **C** . The sample light should begin to blink approximately five times a second (the actual rate is not critical).
9. The calculator display should be blinking and appear as shown below.



0.00

If the display is not 0.00, but some (possibly different) small numbers (say, a few hundredths), you probably moved the cursor when you pressed **O** or **C** . In such a case, return to step 6 and proceed from there.

NOTE

Read step 10 before performing it.

10. Slowly slide the cursor along the line from point N toward point A. As you move the cursor the digits in the display will change. The object of this step is to verify that the digits in the display change in the proper fashion (i.e., 4 is entered following an entry of 3, etc.). Also, verify that all ten digits can be entered.

The number in the display should be a positive number of the form:

$$X_3 . X_2 X_1$$

X_1 will change as the cursor is moved. If the cursor is moved slowly enough, you will be able to see X_1 cycle through a complete cycle of digits in the order: ...0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 0...

For every complete cycle of X_1 , X_2 should increment by one. It should increment when X_1 changes from 9 to 0. Continue moving the cursor until you have verified that X_2 increments properly from 1 through 9.

X_3 is checked later in the procedure.

Polarity Check

11. Slide the cursor to point B. The number in the display should be negative.
12. Press **C**. The sample light should stop blinking, and the calculator display should be:

13. Press **C**. The sample light and the display should resume blinking.

Stop Check



14. Press: **RUN STOP**

The sample light and the display should stop blinking.

15. Press: **RUN STOP**

The sample light and the display resume blinking.

16. Press: **C**

The display should be:

S Check

17. Press **S** several times. Each time **S** is pressed the sample light and the display should blink once.
18. Pick up the cursor. You should hear a beep lasting approximately three-quarters of a second, and the sample light should go out. Remove the paper and the tape from the digitizing surface.
19. Press: **RUN STOP**

Digitizing Area Size Check

20. Referring to Figure 2, position the cross-hairs over point C.
21. Press: **RUN STOP**
22. If you entered a 1 (for the x coordinate) in step 4, perform step 23 and 24 and skip steps 25 and 26. If you entered a 0 (for the y coordinate) in step 4, skip step 23 and 24 and perform steps 25 and 26.
23. Press **C** and then **C**. The sample light should begin blinking.

Referring to Figure 2, slide the cursor along the path indicated by the horizontal dotted line. Slide the cursor off the edge of the platen. As the cursor moves through the region marked D, you should hear a beep lasting approximately three-quarters of a second, and the sample light should go out.

24. The number in the display must be 17 or greater.

The Digitizer Platen

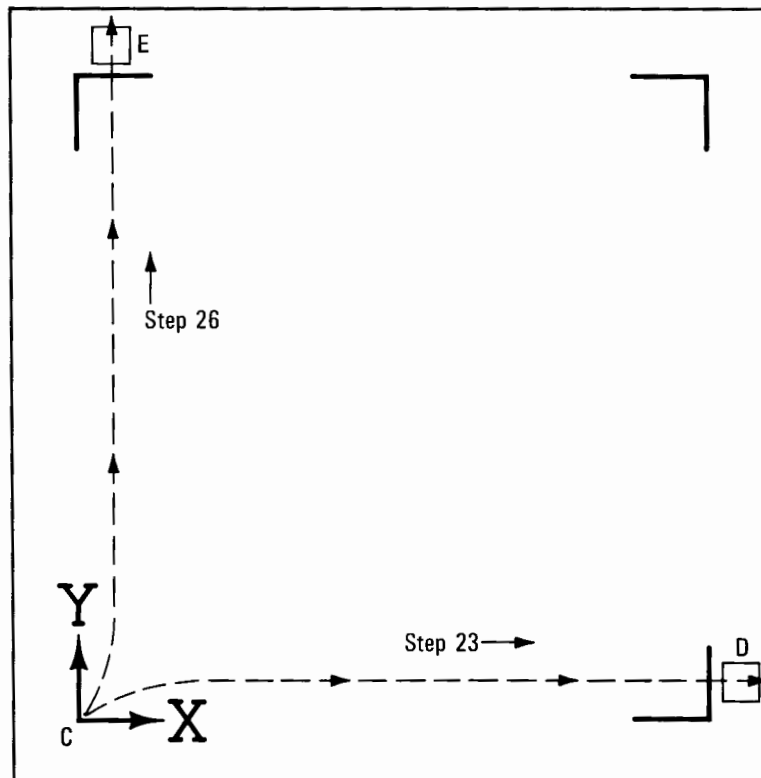


Figure 2. Cursor Motion During the Digitizing Area Size Check

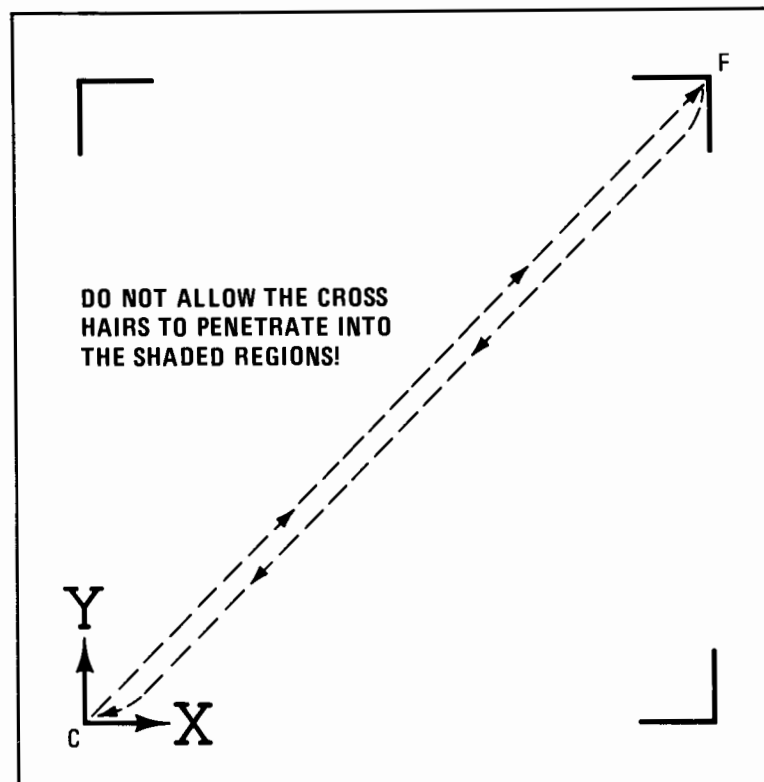
25. Position the cross-hairs over point C again. Press and then press ; the sample light should begin blinking. Referring to Figure 2, slide the cursor vertically toward the edge of the platen. As the cursor moves through the region marked E, you should hear a beep lasting approximately three-quarters of a second, and the sample light should go out.
26. The number in the display must be 17 or greater.
27. Press . The sample light should stop blinking.

 H Check

28. Referring to Figure 3, position the cross-hairs over point C.

Press

The Digitizer Platen

Figure 3. Cursor Motion During the **H** Check

29. Press **C**. The sample light should begin blinking.

NOTE

Read step 30 before performing it.

30. Referring to Figure 3, slowly slide the cursor toward point F. As the cursor is moved you should see numbers in the display in the form:

$$X_3 . X_2 X_1$$

Verify that each time X_2 changes from 9 to 0, X_3 increments by one count.

A little past midway from point C toward point F, the number in the display will assume the following form:

$$X_4 X_3 . X_2 X_1$$

While proceeding with the remaining steps of the check, verify that X_4 increments by one count each time X_3 changes from 9 to 0.

31. When the cross-hairs are positioned over point F, note the number in the display and press **[H]** . The sample light should continue to blink.
32. Pick up the cursor. You should not hear a beep and the sample light should continue to blink.
33. Referring to Figure 3, position the cross-hairs over point C. Without moving the cursor, press **[H]** .
34. The numbers in the display should be the same as noted in step 31. If the number is not the same, you probably moved the cursor during step 33; return to step 28 and try again.
35. Referring to Figure 3, slowly slide the cursor toward point F. Verify that the number being displayed increments properly as it increases in value.
36. When the cross-hairs are positioned over point F, press **[H]** .
37. Slide the cursor back to point C. Press **[H]** again.
38. Repeat the routine as described in steps 36 - 38 three additional times.
39. Referring to Figure 3, again slowly slide the cursor toward point F. Continue to verify that the number being displayed increments properly. Approximately midway between point C and point F, the number in should change from 99.99 to 0.00. It is not necessary to observe the actual change; it is sufficient to observe that the number appears to increment from 0.00.

Reset Check


40. When the cross-hairs are positioned over point F, press **[H]** . Pick up the cursor; while holding it several inches above the digitizing surface, press **[H]** . You should hear a beep lasting approximately three-quarters of a second, and the sample light should go out. Press **[C]** .

Shim Check



NOTE


If the Shim Check fails while using a shim whose thickness is unknown, check the thickness of the shim before requesting assistance. The shim should not be thicker than .025 inches; however, many digitizers will pass the Shim Check with shims somewhat thicker than .025 inches.

41. Place the shim anywhere on the digitizing area.
42. Place the cursor on top of the shim. Press **[O]** . The sample light must come on, and the digitizer must not beep during or after the pressing of **[O]** .
43. Remove the cursor from the digitizing surface. You should hear a beep.

44. Press .

If you have completed the Function Check for the x coordinate only, continue with step 45 to check the digitizer function for the y coordinate. If you have completed the procedure for both the x and y coordinates, this completes the procedure.

45. Press  .

Enter 0 (y coordinate) and press . Replace the sheet of paper (shown in Figure 1) and repeat the function check procedure starting with step 6.

```
HP9864A
DIGITIZER
TEST PROGRAM
```

```
COORDINATE TO BE
DISPLAYED: ENTER
1 FOR X, 0 FOR Y
```

Accuracy Check

The procedure in this section verifies the accuracy of the digitizer. The procedure assumes that the digitizer has successfully passed the Function Check.

1. If the calculator and digitizer are not connected, refer to Section 1 of this manual.

Document Alignment

2. Referring to Figure 4, place the Sample Data Overlay on the digitizing area. Place a single piece of tape across the upper left-hand corner of the overlay. Prepare three other short pieces of tape for the other corners; they will be used later.

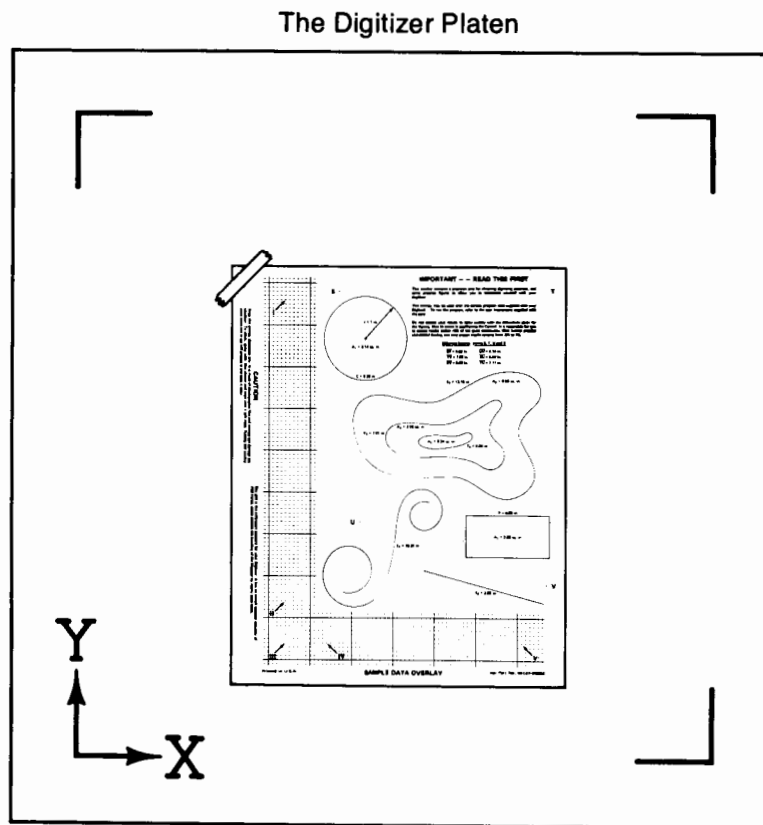


Figure 4. Initial Placement of the Sample Data Overlay

3. Turn the calculator on. Insert the Utility and Test Cartridge into the tape drive. To load the Document Alignment Program from file –50:

Press  50 


When the tape drive halts:


Press  

4. Switch the digitizer on.
5. Position the cursor exactly over point I on the overlay.

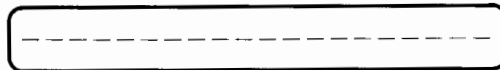
NOTE

From this point until the end of this procedure, move the cursor only as directed.





6. Press 
7. Place one hand on the overlay to keep it from moving. Leave it on the overlay until step 15 has been completed.
8. Slide the cursor to point III. Position the cross-hairs exactly over point III.

Press 

9. Before moving the overlay and the cursor, note the value in the display. If the value is negative, move the overlay to the right. If the value is positive, move the overlay to the left. When point III comes within 0.5 inches of the digitizer-axes parallel point, the digitizer will begin to slowly beep. When point III comes within 0.2 inches of the parallel point, the digitizer will beep faster. When point III is exactly over the parallel point, the digitizer will emit a continuous beep and the display will appear as shown below.



Display at Parallel Point

10. When point III is positioned over the parallel point, press  and carefully tape the three remaining corners to the platen.
11. Position the cursor exactly over point I.
Press 
12. Slide the cursor to point III. Align the cross-hairs exactly over the point and press  .
The digitizer should emit a continuous beep.
If these conditions are not met, return to step 5 and repeat the alignment procedure.
13. When the overlay is properly aligned, press .

Coordinate Value Check

14. Load file –18 from the Utility and Test Cartridge.

Press  18 

15. Slide the cursor to point III. Position the cross-hairs exactly over point III.

16. Without moving the cursor, press **0** .
17. Press **END** **RUN STOP** , enter 1 (x coordinate) and press **RUN STOP** . Select either yes or no for beep as you desire.
18. Slide the cursor to each of the points **I**, **II**, **III**, **IV** and **V**. At each point, position the cross-hairs exactly over the point and press **S** . Compare the value displayed for each point with these shown below.

Point **I** = $0.00 \pm .01$
 Point **II** = $0.00 \pm .01$
 Point **III** = $0.00 \pm .01$
 Point **IV** = $1.00 \pm .01$
 Point **V** = $5.70 \pm .01$

NOTE

The tolerance of $\pm .01$ assumes that the ambient temperature is within the range of 15°C to 30°C . If the ambient temperature is within the range of 0°C to 15°C , or within 30°C to 50°C , the tolerance is $\pm .03$ instead of $\pm .01$.

19. Press **RUN STOP** **END** **RUN STOP** , enter 0 (y coordinate) and press **RUN STOP** .
20. Slide the cursor to each of the points **I**, **II**, **III**, **IV**, and **V**. At each point position the cross-hairs exactly over the point and press **S** . Compare the value displayed for each point with those shown below.

Point **I** = $8.20 \pm .01$
 Point **II** = $1.00 \pm .01$
 Point **III** = $0.00 \pm .01$
 Point **IV** = $0.00 \pm .01$
 Point **V** = $0.00 \pm .01$



3

Digitizer Control

Control Instructions

I/O Control

FLAG   

Stack

- 1 → X

DATA   

+ (any number) → X

The digitizer requires that the calculator I/O control be established with a - 1 parameter for the FLAG instruction and a positive parameter for the DATA instruction (positive true data logic).

The calculator, when first switched on, automatically sets a - 1 for the FLAG instruction. The calculator also automatically sets negative-true logic. You must reset the data logic level the positive true for the digitizer by entering a positive value into X and executing the DATA key sequence.

Basic Data Input

The calculator inputs data from the digitizer in the following form:

(x coordinate) , (y coordinate) (CR) (LF)

The general program format used to continuously input data is shown below.

The DATA instruction (step 0001) sets a positive true logic sense. The x-coordinate value is input into the X register by the first READX (step 0003) and the instruction is terminated by the comma (.). The second READX (step 0005) inputs the y-coordinate value into the X register (which automatically enters the x-coordinate value into the Y register) and the instruction is terminated by the carriage return (CR) and line feed (LF) characters. The resulting stack contents are:

```
0000 CLEAR
0001 DATA 2
0003 READX 2
0005 READX 2
0007 GOTO 0003
0009 END
```

x coordinate → Y

y coordinate → X

Data Input with a Beep

The program format shown below is used to input data from the digitizer and sounds a beep after each point has been entered.

Although this program is essentially the same as the basic data-input program, it adds both DELIM and WBYTE instructions. The DELIM instruction (steps 0003 to 0005) sets the carriage return character (decimal value 13) as a terminating input delimiter. After the two READX instructions input the coordinate values, the WBYTE instruction outputs the value in X to the digitizer, causing it to beep. Any positive value between 0 and 255 can be output with the WBYTE instruction.

```
0000 CLEAR
0001 DATA 2
0003 1
0004 3
0005 DELIM 2
0007 READX 2
0009 READX 2
0011 0
0012 WBYTE 2
0014 GOTO 0007
0016 END
```

4

Sample Programs

The Line Length and Area Program


This section contains a description of, and instructions for using, the Digitizer Line Length and Area Program; this program is prerecorded on the Utility and Test Cartridge (HP Part No. 09815-10004).




The Line Length and Area Program can be tailored to run as a general area (numerical integration) program or as a line length program. You can also specify plotter output, which causes the HP 9862A Plotter to plot the coordinates of each data sample as it is digitized.

1. Connect the equipment and prepare the plotter, if it is available, for a 10 × 10 inch plot. The calculator must be switched off when the Plotter and the General I/O Interfaces are connected.



CAUTION

BE SURE THAT THE CALCULATOR, THE DIGITIZER, AND
THE PLOTTER ARE TURNED OFF WHILE THEY ARE BEING
CONNECTED TOGETHER.

2. Locate the Sample Data Overlay (an 8 × 10 inch piece of clear film with figures on it, HP Part No. 09107-90002). Attach it to the digitizing surface with small pieces of tape across the corners. The overlay will be used as the data to be digitized. At first, you may not get results that agree closely with the values given on the overlay, especially when the continuous mode is used to digitize. Within a very short while, however, your results will probably be within five percent of the indicated values. With further practice and careful tracing, you can expect errors of less than one percent.
3. Place the cursor anywhere within the digitizing area and press  (on the cursor). This sets an origin.
4. Insert the Utility and Test Cartridge into the calculator tape drive and load file -52.


Press  52  

When the tape drive halts:

Press  

The Area Program


Initial Printout:

5. To select the required program, answer each printed question. To answer "yes", enter 1 into X and press . To answer "no", enter 0 into X and press




```
9864A DIGITIZER
SELECT PRGM:
1=YES      0=NO
AREA?
```

To select the area program:

Press .


```
ONG. 'E' ?
```


6. Notice that an initial value for Epsilon is now in the display (.02). Epsilon is the radius of a circle that will be centered on the first point to be digitized. If the cursor's cross-hairs reenter that circle, the program assumes that a closed figure has been completely digitized. To set a value for E other than .02, you enter the desired value and press .

```
0.02
```

```
PLOTTER?
```

E should be greater than zero. If E equals zero, closure cannot occur. If E is too large, it will cause inaccurate results while digitizing in the continuous mode; a good range of values is from .02 to .05.

For this example, press  to set .02 for E.

7. For this example, plotter output is not required. Enter 0 and press .
8. The program initialization is now complete and the program is ready to digitize.

```
DIGITIZE:
```

NOTE

While the program is digitizing, the calculator display is blanked. The display will return after either the STOP key is pressed (to halt the program) or the program detects closure and automatically stops.

9. Trace figure A₇ on the overlay. Digitize discrete points by pressing **S** each time the cursor's cross-hairs are positioned over one of the corner points. Continue digitizing around the figure. Be sure to return to the corner at which you started, and digitize it again. When you return to a point within a distance of .02 inches from the first corner digitized, you will see the following printout:

```
PERIMETER= 6.00
AREA=      2.00
```



NOTE

If you cannot cause the program to detect closure, you must press **Ⓡ** and restart the program (return to step 4b).

10. Repeat the entire program by pressing **Ⓡ**. Reselect the area program, change the value for E to .05 and select "no" for plotter output. Using the continuous mode **C**, digitize the circle, A₁. When you digitize in the continuous mode, be sure to terminate the mode (by pressing **C** again) after the figure has been completely traced and the program has detected closure.

The Line Length Program

To run the line length program, you press **Ⓡ**.

1. To select the line length program, answer "no" to the "AREA?" question, by entering 0 and pressing **Ⓡ**.

2. To select the open figure routine, change E to .05 inch:

Press **Ⓡ** .05 **Ⓡ**

Initial Printout

```
9864A DIGITIZER
```

```
SELECT PRGM:
1=YES      0=NO
```

```
AREA?
```

```
LINE LENGTH
OPEN FIGURE?
```

```
CHG. 'E' ?
```

```
0.05
```

```
PLOTTER?
```

3. If you have an HP 9862A Plotter in your system, the plotter output routine can be used to plot each point as it is digitized. To answer yes to the plotter question, enter 1 and press **RUN STOP**.

SCALE MULT.?

4. If you select plotter output (by entering 1 into X and pressing **RUN STOP**), you may also specify a plotter scale factor. For instance, if a scale factor of 2 were specified, the plot would be exactly twice as large as the digitized figure.

To specify the scale factor, enter the number into the X register (in place of 1, which the program has entered) and press **RUN STOP**.

2.00

DIGITIZE:

For this example enter 2 (for a plot twice as big) into the X register and press **RUN STOP**.

NOTE

When using the plotter output routine, the location of the origin on the digitizer corresponds to the plotter's lower-left graph limit (coordinates 0,0). Since the plotter only accepts coordinates which are in the upper-right quadrant (positive numbers), the plotter will plot only data points which are digitized above, and to the right of the origin.

The program is now ready to digitize. The open figure line length program uses the same automatic closure mechanism used in the area program (see page 18). However, to simulate closure when digitizing an open figure, the program must know the last point to be digitized; you accomplish this by first specifying the end-point of the open figures. The end-point is specified by positioning the cursor over that point and pressing **S**. That point is not used by the line-length algorithm, but it is necessary to enable the program to stop automatically. After specifying the end-of-line point, you may begin digitizing from the opposite end-point either with **C** or **S**. When you again digitize the end-of-line point, the program will detect closure, compute and print the total line length, and halt.

5. Digitize I_5 on the sample overlay. After specifying the end-of-line point, by pressing **S**, slide the cursor to the remaining end-point and press **C**. Trace the figure carefully. The program should detect the end-point and the following result should be printed:

LENGTH= 10.37

NOTE

If you are unable to cause the program to detect closure, you must press **RUN STOP** and restart the program by pressing



Remember: When digitizing an open figure, you must first specify the end-point by digitizing it with a single sample; then you can digitize the figure to that point with **C** or **S**.

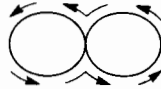
6. Restart the program, but select the "closed figure" line length program. For this program, the digitizing procedure is the same as that used for the area program, trace around the figure until you retrace the first point digitized. The program should then detect closure, print the computed length, and halt.
7. Digitize A_3 ; however, this time set E to .0099 and use the continuous mode. (Setting E to .0099 completely negates the partial smoothing.) Trace very slowly and very carefully. Do not be surprised if the result falls in the range of from 8.2 inches to 8.6 inches. In fact, the slower you trace the line, the worse the error is likely to be! The amount of error depends upon the amount of jitter, which in turn depends upon the direction in which you are moving the cursor, how fast you are moving it, and some other intangibles.
8. Now digitize A_3 again, except set E to .05 inches and use the continuous mode. As before, trace the line slowly and carefully. This time your result should be quite acceptable.

You can practice digitizing by using the line length program with the other figures on the overlay.

Applying the Area Program

When finding the area of a closed figure, notice if the figure has borders that cross each other, as in a figure eight. When digitizing figures with that property, follow this rule: Never digitize along a path that crosses a border that has already been digitized.

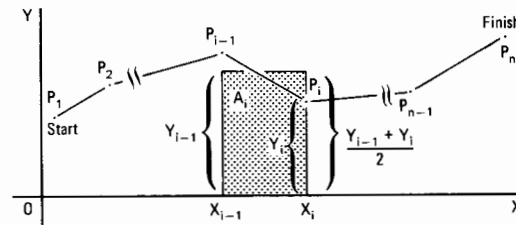
The path followed may touch or partially coincide with a previously digitized border, but the path must not cross. A figure eight, for instance, would be digitized as shown below.



To use this program to find the area under a curve, treat the area as a closed figure. The borders of this closed figure would be: 1) the curve itself, 2) the segment of the axis the independent variable against which the curve was plotted and 3) the lines (if they exist) that are drawn perpendicular to the axis of the independent variable and pass through the end points of the interval to be digitized.

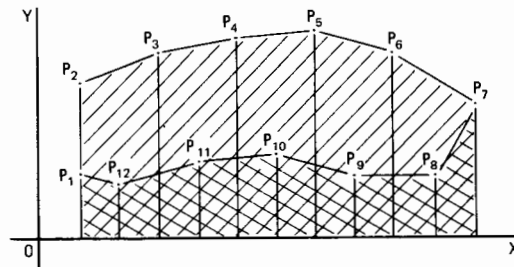
The Integration Algorithm

The area program calculates the required area by summing the areas of rectangles described by the incoming data.



$$AREA = \left| \sum_{i=2}^n A_i \right| \text{ where } A_i = \frac{\Delta X (Y_{i-1} + Y_i)}{2}, \text{ and } \Delta X = X_i - X_{i-1}$$

The sign of A_i depends upon the direction of cursor movement that produced each particular A_i . The signs of the individual A_i are useful, and allow the program to compute the area of closed figures.



In the above figure, the area of the cross-hatched region is automatically removed from the result; thus, only the area of the single-lined region remains as the answer. This is a direct consequence of the changes in sign of each individual A_i , as the direction of cursor movement alters while the figure is being digitized.

Program Listing

0000	CLRA+J			0055	S	
0001	0			0056		
0002	#REGS			0057		
0003	CFG	1	} Initial register and flag preparation.	0058		
0004	CFG	2		0059		
0005	CFG	3		0060	0	
0006	CFG	4		0061	=	
0007	1			0062	N	
0008	3			0063	0	
0009	ENTER↑		} DELIM Instruction: set CR (13) as an input delimiter.	0064	LINE	
0010	0			0065	LINE	
0011	DELIM	2	} DATA Instruction: set positive-true logic sense.	0066	A	
0013	DATA	2		0067	R	
0015	SPACE			0068	E	
0016	SPACE			0069	A	
0017	SPACE			0070	?	
0018	1			0071	LINE	
0019	PRNTα			0072	LINE	
0021	9			0073	LINE	
0022	8			0074	ENDα	
0023	6			0075	STOP	
0024	4			0076	IF 0	
0025	A			0077	GOTO	0082
0026				0079	SFG	1
0027	D			0080	GOTO	0114
0028	I			0082	1	
0029	G		} Print the title and select either the area or length program.	0083	PRNTα	
0030	I			0085	L	
0031	T			0086	I	
0032	I			0087	N	
0033	Z			0088	E	
0034	E			0089		
0035	R			0090	L	
0036	LINE			0091	E	
0037	LINE			0092	N	
0038	S			0093	G	
0039	E			0094	T	
0040	L			0095	H	
0041	E			0096	LINE	
0042	C			0097	0	
0043	T			0098	P	
0044				0099	E	
0045	P			0100	N	
0046	R			0101		
0047	G			0102	F	
0048	M			0103	I	
0049	:			0104	G	
0050	LINE			0105	U	
0051	1			0106	R	
0052	=			0107	E	
0053	Y			0108	?	
0054	E			0109	LINE	

If the length program is selected, go to step 82.

If the area program is selected, set flag 1 and go to step 114.

Specify the type of figure: Open or Closed. If closed, set flag 2.

```

0110 LINE
0111 ENDα
0112 STOP
0113 IF 0
0114 SFG      2
0115 .
0116 0
0117 2
0118 ENTER↑
0119 PRNTα
0121
0122
0123 C
0124 N
0125 G
0126 .
0127 '
0128 '
0129 E
0130 '
0131
0132 ?
0133 LINE
0134 LINE
0135 ENDα
0136 STOP
0137 STO      E
0138 PRINT
0139 SPACE
0140 0
0141 PRNTα
0143 P
0144 L
0145 0
0146 T
0147 T
0148 E
0149 R
0150 ?
0151 LINE
0152 LINE
0153 ENDα
0154 STOP
0155 IF 0
0156 GOTO     0195
0158 SFG      4
0159 1
0160 PRNTα
0162 S
0163 C
0164 A
0165 L
0166 E
    
```

Select the value for 'E'.

Specify if plotter output is desired.
 Yes - set flag 4.
 No - go to step 195.

```

0167
0168 M
0169 U
0170 L
0171 T
0172 .
0173 ?
0174 LINE
0175 ENDα
0176 STOP
0177 PRINT
0178 IF SFG 7
0179 GOTO     0195
0181 SPACE
0182 1/X
0183 STO      F
0184 0
0185 ENTER↑
0186 1
0187 0
0188 RCL      F
0189 *
0190 STO      F
0191 0
0192 RCL      F
0193 SCALE
0195 PRNTα
0197 D
0198 I
0199 G
0200 I
0201 T
0202 I
0203 Z
0204 E
0205 :
0206 LINE
0207 LINE
0208 LINE
0209 ENDα
0210 READX    2
0212 STO      A
0213 STO      G
0214 READX    2
0216 STO      B
0217 STO      H
0218 X≠Y
0219 WBYTE    2
0221 IF SFG 4
0222 PLOT
0224 IF SFG 2
0225 GOTO     0232
0227 0
    
```

Enter the scale multiplier and set the plotter SCALE.

Store the coordinates of the first point:
 X is stored in A and G.
 Y is stored in B and H.
 Plot the point (if plotter is specified).

Closed Figure - go to step 232.
 Open Figure - store 0 in Reg. G and H.

```

0228 STO G
0229 STO H
0230 PEN↑
0232 READX 2
0234 STO C
0235 READX 2
0237 STO D
0238 X≠Y
0239 WBYTE 2
0241 IF SFG 4
0242 PLOT
0244 RCL G
0245 -
0246 2
0247 Y↑X
0248 X≠Y
0249 RCL H
0250 -
0251 2
0252 Y↑X
0253 +
0254 SQRT
0255 RCL E
0256 IF X≥Y
0257 GOTO 0232
0259 ROLL↓
0260 STO+ I
0261 RCL C
0262 RCL G
0263 -
0264 2
0265 Y↑X
0266 RCL C
0267 RCL D
0268 RCL B
0269 2
0270 Y↑X
0271 +
0272 SQRT
0273 RCL E
0274 IF X≥Y
0275 SFG 3
0276 IF SFG 1
0277 GOTO 0288
0279 IF SFG 3
0280 GOTO 0303
0282 RCL C
0283 STO G
0284 RCL D
0285 STO H
0286 GOTO 0232
0288 RCL C
0289 RCL G
    
```

Input the next point coordinates:
X is stored in C.
Y is stored in D.
Plot the point if specified.

Check for EΔI min > E. If <E, go to step 232. If >E, accumulate in Reg. I.

Check for closure. If closed - set flag 3.

Check flag 1 (area program). If set, go to step 288.

Check flag 3 (closed figure). If set, go to step 303.

Store the coordinates from Reg. C into G and Reg. D into H. Go to step 232.

```

0290 -
0291 RCL D
0292 RCL H
0293 +
0294 *
0295 2
0296 +
0297 STO+ J
0298 IF SFG 3
0299 GOTO 0325
0301 GOTO 0282
0303 IF SFG 2
0304 GOTO 0325
0306 RCL I
0307 PRNTα
0309 L
0310 E
0311 N
0312 C
0313 T
0314 H
0315 =
0316 PRINT
0317 LINE
0318 ENDα
0319 SPACE
0320 SPACE
0321 SPACE
0322 SPACE
0323 GOTO 0359
0325 RCL I
0326 PRNTα
0328 P
0329 E
0330 R
0331 I
0332 M
0333 E
0334 T
0335 E
0336 R
0337 =
0338 PRINT
0339 LINE
0340 ENDα
0341 IF CFG 1
0342 GOTO 0319
0344 RCL J
0345 PRNTα
0347 A
0348 R
0349 E
0350 A
    
```

Compute area and accumulate in Reg. J.

If the figure is complete (closure) go to step 325. If not, go to step 282.

Check flag 2 (closed figure). If closed, go to step 325.

If an open figure, print "LENGTH = ", then go to step 359.

Print "PERIMETER = ", then go to step 319 if the length program was specified.



```

0351 =
0352 PRINT
0353 LINE
0354 LINE
0355 LINE
0356 LINE
0357 LINE
0358 ENDα
0359 IF SFG 4
0360 PENT
0362 0
0363 STO A
0364 STO B
0365 STO C
0366 STO D
0367 STO G
0368 STO H
0369 STO I
0370 STO J
0371 STOP
0372 GOTO 0003
0374 END

```

Print "AREA = ", then go to step 319.

Raise the plotter pen.

Clear all of the data registers except Reg. E and F.

Go to step 3.

Program Details

The Area Program

The area program may be used to find either the area of any closed figure or the area under a curve. The program can detect the fact that a closed figure has been completely digitized; this is called "detecting closure" and involves an adjustable tolerance called Epsilon (E). Epsilon is the value that determines how closely the cursor must return to the starting point before closure will occur. Also, Epsilon determines the minimum distance between (Δ min) points which are used by the area computation routine.

Automatic Closure

To accomplish "automatic closure", the area program stores the first point digitized (P_1); then a circle of radius Epsilon (Epsilon may be determined by the operator) is drawn around P_1 . Closure occurs when some P_n (lying inside the circle) is accepted, after at least one point lying outside the circle has been accepted. After the computations for P_n are completed, P_1 is compared with P_n ; if the distance from P_1 to P_n is less than the value for Epsilon, closure is put into effect.

The Line Length Program

The line length program can be used to find the length of any line or to find the distance between points. The program is selected by answering "no" to the "AREA?" (program) question, and by specifying the type of figure (either open or closed) to be digitized.

The program can detect the fact that either an open or closed figure has been completely digitized. This procedure is called "detecting closure" and involves an adjustable tolerance called Epsilon (E). E is the value that determines how closely the cursor must return to the starting point before closure will occur. The line length program utilizes the same closure mechanism used in the area program (see Automatic Closure above).

Epsilon is also the minimum distance ($\Delta l \text{ min}$) between points which are used by the distance measuring algorithm. Selection of a $\Delta l \text{ min}$ for continuous sampling is an important consideration involved in using this program. If $\Delta l \text{ min}$ is larger than .05 inches, curves with a radius of less than about .125 inches cannot be accurately digitized. This is because the minimum distance between successive points becomes significant when compared to the degree of curvature of the line to be digitized. On the other hand; if $\Delta l \text{ min}$ is less than .02 inches, the jitter accompanying a slow and deliberate movement of the cursor can induce a large error in the result. (For further information about this unavoidable jitter, see the section titled "Smoothing" in the Digitizer Peripheral Manual.)

Within the above limits, $\Delta l \text{ min}$ should be selected to provide the best compromise between ease of closure and the desired accuracy. In some cases, it may be desirable to set $\Delta l \text{ min}$ low enough such that every point digitized is used by the distance measuring algorithm. To do this, set $\Delta l \text{ min}$ to .0099 inches. This will allow every (different) point digitized to contribute to the result, but still allow closure. However, closure will be difficult to achieve, since the cross-hairs must return exactly to the coordinates of the first point digitized.

The Distance Measuring Algorithm

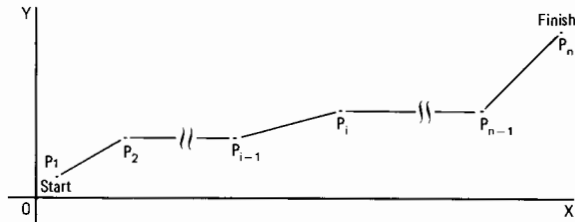
The line length program computes a distance along a path defined by a series of points. To minimize the effect of jitter, the only points used in the distance measuring calculations are those that meet a minimum distance requirement involving $\Delta l \text{ min}$. The application of this minimum distance requirement produces a smoothing effect that almost completely corrects for the effect of the jitter. (This type of smoothing is called "partial smoothing", as opposed to a more sophisticated method, which produces fully smoothed results.)

Partial smoothing is achieved by not accepting points whose distances from the previously accepted point are less than, or equal to, $\Delta l \text{ min}$.

The distance from P_1 to P_n along a path of n points meeting the minimum distance requirements is:

$$\overline{P_1 P_n} = \sum_{i=2}^n \overline{P_{i-1} P_i} \quad \text{where} \quad \overline{P_{i-1} P_i} = \sqrt{(X_i - X_{i-1})^2 + (Y_i - Y_{i-1})^2}$$

is the straight line distance from P_{i-1} to P_i .



To measure a curved line, a number of closely spaced samples are taken, resulting in an approximation of the length of the curved line.

Basic Digitizer Program

This program requires that an HP 9862A Plotter and an HP 98132A Plotter Interface be connected to the Calculator-Digitizer System. Refer to Section 1 of the Plotter Interface Manual for information concerning plotter installation.

Program Operation

As you trace a figure on the digitizer, the data is simultaneously output to the plotter which draws a scaled copy of the figure. You can adjust the plotter scale to draw a figure that is either larger or smaller than the original.

Running the Program


Position a sheet of paper on the plotter platen and set the Graph-Limit controls for the desired plot area.

Insert the Utility and Test Cartridge into the tape drive. To load the Basic Digitizer Program from file -51:

Press **CLEAR** **51** **↺** **LOAD**

When the tape drive halts:

Press **END** **RUN STOP**


Enter the plot-area scale values into the stack registers in the following order and press .

X_{min} → T
 X_{max} → Z
 Y_{min} → Y
 Y_{max} → X

BASIC DIGITIZER
 EXAMPLE

ENTER PLOTTER
 SCALE VALUES.






Position the Sample Data Overlay or any other figure on the digitizer platen. Set the origin with the digitizer cursor by pressing . This origin corresponds to the origin established on the plotter.


BASIC DIGITIZER
 EXAMPLE

ENTER PLOTTER
 SCALE VALUES.

-10.00
 10.00
 -10.00
 10.00

SET ORIGIN AND
 DIGITIZE.

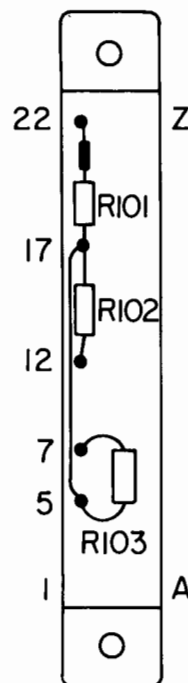
Select one of the figures on the overlay and slide the cursor to the desired starting point. Press  and carefully trace the figure. The plotter will simultaneously draw a similar figure. When you have completed the figure press  on the calculator keyboard to raise the plotter pen and terminate the program. Press  on the cursor.

To repeat the program press .

Appendix

HP 98134A Option 064 Interface Connector










Pin	I/O Line	Wire Color
A	I6	Grn
B	I7	Blu
C	GND	Blk
7	I/O	Wht/Blk
8	I5	Wht/Gry
9	I1	Orn
10	I0	Yel
11	I3	Brn
12	STP	Wht/Blk/Grn
18	I4	Wht/Vio
19	I2	Red
21	FLG	Wht/Blk/Red
22	CTL	Wht/Blk/Orn



Material List

Item	HP Part No.	Qty.	Description
R101, 102, 103	0683-2025	3	Resistor R-F 2000Ω .05%
	09864-00203	1	Access Panel
	98032-01201	1	Holding Bracket
	98032-01202	1	Card Retainer
	2360-0117	4	6-32 .375 inch Screw
	1251-2048	1	2 × 22 PC Connector
	0380-0962	2	Hex Standoff
	0360-1617	5	Forked Terminal Stud
	1390-0088	4	Retainer
	1390-0214	4	Stud Fastner
	2200-0107	4	4-40 .375 inch Screw

Error Messages

SELECT CODE ERR	Both interfaces are set to the same select code – change one of the settings immediately!
* OVERFLOW	Number or result exceeds calculating range.
* SQRT OF NEG #	
* DIVISION BY ZERO	
* LOG OF # <=0	
* NO I/O DEVICE	General I/O Interface is either not connected or set to another select code.
ILLEGAL ADDRESS	Improper step address or storage register specified.
ILLEGAL ARGUMENT	Range exceeded for DELIM, FIELD, WBYTE ,AND, OR, ROT, or FLAG instructions.
MEMORY OVERFLOW	Program instruction, storage register assignment, or program loaded from tape exceeds available memory.
GOSUB OVERFLOW	More than seven subroutines (including special functions) nested at a time.
KEY NOT DEFINED	Special function just called is not defined.
IMPROPER SYNTAX	Incorrect use of        or  .
* CHECKSUM ERROR	Program or data loaded into calculator not identical to that in file; this usually indicates a dirty tape head or a worn tape.
* VERIFY FAILED	Program or data in file not identical to that in calculator.
WRONG FILE TYPE	Attempting to load an empty, extra, or binary file; recording on an extra file.
END OF TAPE	End of tape reached during MARK operation. Also indicates a broken or defective tape; if the tape does not appear to be broken, (advance it using the drive wheel), replace the cartridge, press  , and continue.
PROTECTED TAPE	The cartridge RECORD slide is positioned to prevent MARK and RECORD operations.
SECURED MEMORY	Attempting to list, edit, or record a secured program.
MISSING FOR STMT	
LABEL NOT FOUND	
FILE NOT FOUND	
CARTRIDGE OUT	
MISSING GOSUB	

*These messages are suppressable. See "Flags" in Section 3 of the 9815A Operating and Programming manual.

HEWLETT  PACKARD



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