Hewlett-Packard 9815A/S Calculator
98134A General I/O Interface
Operating and Service

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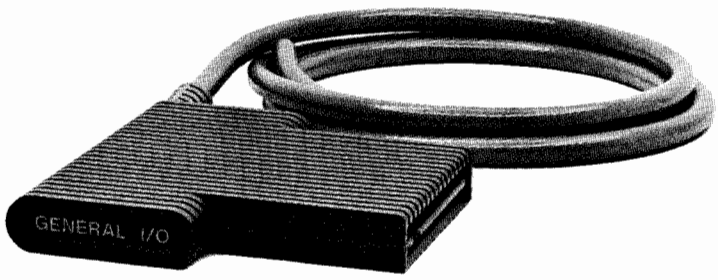

HP 98134A General I/O Interface

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(For World-wide Sales and Service Offices see back of manual.)

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Introduction

The HP 98134A General I/O Interface provides an HP 9815A Calculator with an 8-bit parallel, character serial interface to a wide variety of peripheral devices. The interface transfers data in a "half-duplex" fashion; that is, it can input and output data, but not both at the same time. The interface provides buffer-storage for each character (byte) of input or output data, and all lines are compatible with standard TTL levels.

This manual describes how to install, operate, and service the General I/O Interface. If you have purchased an interface prewired with an optional connector, see its accompanying Operating Note for additional installation and operating instructions.

Hardware Description

The General I/O Interface consists of a circuit board inside a case which plugs into either I/O channel on the calculator and a 7.6m (25 foot) cable. One end of the cable is connected to the circuit board, while the other end is left unterminated. Cable wire colors and "pin outs" are shown on page 35.

Technical Specifications

I/O Format

The interface sends and receives information in an 8-bit parallel, character-serial fashion. All usable ASCII-coded[1] characters are listed in the Appendix.

Although the calculator handles only ASCII-coded information, the interface can transfer data in any 8-bit binary code. A sample code-conversion program is described in Section 2.

Data Input Lines

Eight input lines are available. Each has a TTL load and a resistive divider consisting of 1KΩ to +5V and 1.5KΩ to ground.

Data Output Lines

Eight output lines with open-collector SN 7406 TTL inverters are available.

[1]American Standard Code for Information Interchange.

Control Lines

- Device Control ($\overline{CTL}$) – High-to-low transition indicates that the interface either is ready to input data or has data to output.
- Device Ready (FLG) – Peripheral device indicates "output data accepted" or "input data valid" by forcing line low (with negative-true flag logic) or high (with positive-true flag logic). See "Signal Levels".
- I/O Status (I/O) – Indicates whether calculator has started an input operation (high) or an output operation (low).
- Stop ($\overline{STP}$) and (STP) – ($\overline{STP}$) goes low for at last 10ms and (STP) goes high for at last 10 ms when (RUN STOP) is pressed to cancel an I/O operation.

Enable Handshake (ECH)

When the Handshake mode is enabled, the interface cannot drive $\overline{CTL}$ low until the peripheral device forces FLG to a logical 0 state to indicate "ready". When ECH is disabled, the interface does not check the FLG line before driving $\overline{CTL}$ low. See "The FLAG Instruction" in Section 2 for details.

Signal Levels

- Data Lines – The interface can be set to transmit and receive data using either positive-true or negative-true TTL logic levels. (See "The DATA Instruction" in Section 2.) Positive-true logic means that a logical 1 $\geq$ 2.4V = high and a logical 0 $\leq$ 0.7V = low. Negative-true logic means that a logical 1 $\leq$ 0.7V = low and a logical 0 $\geq$ 2.4V = high.
- Control Lines – A bar above each control line name indicates that the line is low when at a logical 1 state (negative-true logic).
- The FLG line can be set to respond to either negative-true or positive-true logic levels by using the FLAG instruction. FLG will respond to negative-true logic when the calculator is switched on. See "The FLAG Instruction" in Section 2 for more details.

Temperature Range

5° C to 45° C Ambient, for both operating and storage.

Power

Provided by the calculator.

Dimensions

Case: 11.1cm (4 3/8 inches) × 11.4cm (4 1/2 inches)

Cable: 7.6 m (25 feet), unterminated. When installed, the interface case extends 6.3cm (2.5 inches) from the back of the calculator.

Interface Options

Each of the General I/O Interfaces listed below is prewired with a connector and ready to use with the indicated calculator peripheral. Each optional interface has a 2.44m (8 foot) cable.

Interface Option:	HP Calculator Peripheral
98134A Opt. 063	9863A Tape Reader
98134A Opt. 064	9864A Digitizer
98134A Opt. 066	9866A Thermal Printer
98134A Opt. 083	9883A Tape Reader
98134A Opt. 084	9884A Tape Punch

Plug-In Procedure

The General I/O Interface can be plugged into either I/O channel on the calculator back-panel. Before plugging in the interface, however, be sure that the calculator is switched off – if not, the calculator will not recognize I/O operations which are executed or programmed. After the interface is plugged in, switch the calculator back on.

If "SELECT CODE ERR" is printed when the calculator is switched on, both interfaces in the calculator are set to the same select code. If this occurs, switch the calculator off **immediately** and change the select code on one of the interfaces .

Memory Usage

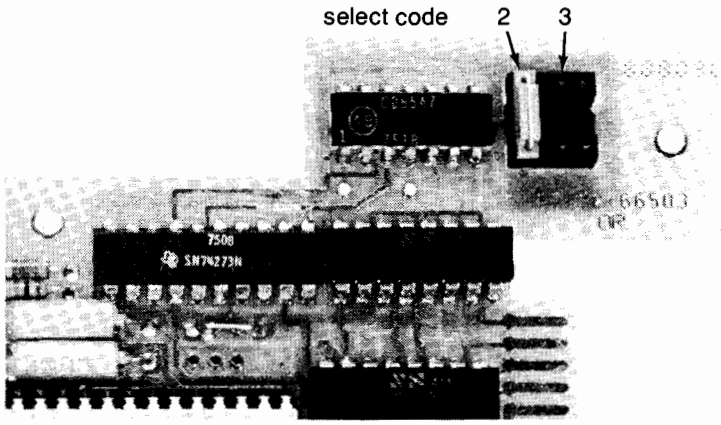
When the General I/O Interface is plugged in, it uses sixteen steps of program memory. This loss of sixteen steps is indicated by the "remaining number of steps" shown in the display when the Program mode is set.

Select Code

Each interface connected to the calculator has a unique address, or select code, so that you can specify which interface should respond to each instruction. This select code is a one-digit number and must be included in each interface operation.

Although the General I/O interface is preset to select code 2 at the factory, you can change the setting to 3 by following this procedure.

1. Switch the calculator and the peripheral device off.
2. Disconnect the interface from the calculator. Remove the four screws on the top of the interface connector and remove the plastic cover.
3. Locate the select code plug (see the next figure), and move it to its alternate position.



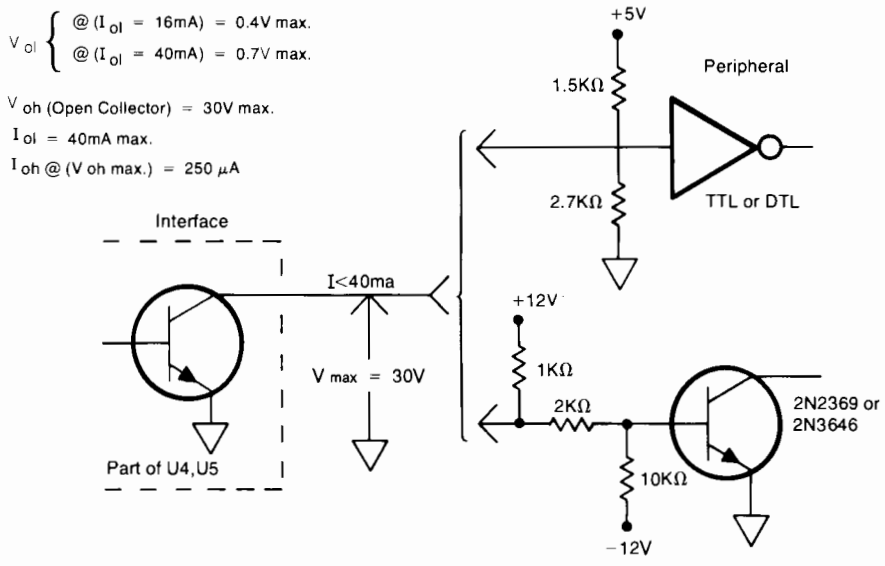
Interface Select Code

4. Replace the plastic cover and secure it with the four screws. Then place a new select code label on the side of the connector to indicate the new code.
5. Reconnect the interface to the calculator; then turn the calculator and the peripheral on. Verify interface operation by executing an I/O instruction (or running a program) which specifies the new select code.

Typical Peripheral Circuits

Receiving Circuits

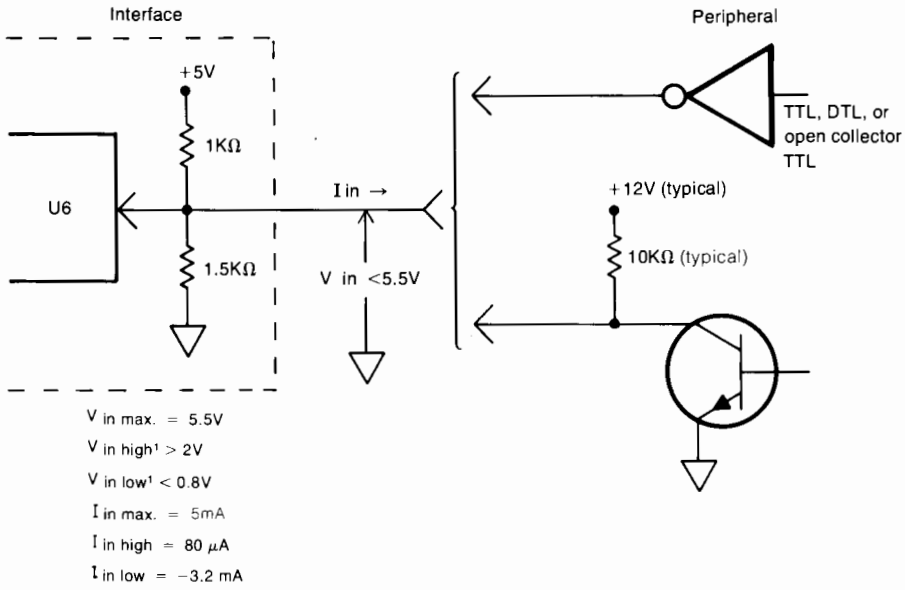
Each interface output line has a device with an open-collector output. The current-sinking capability of each device is 40mA and the breakdown voltage is 30V. Since each output device has an open collector, the peripheral receiving circuit must have a positive pull-up voltage (not to exceed 30V) and must be restricted to sourcing (back to the transmitter) less than 40mA. Typical receiving circuits are shown here:



Typical Receiving Circuits

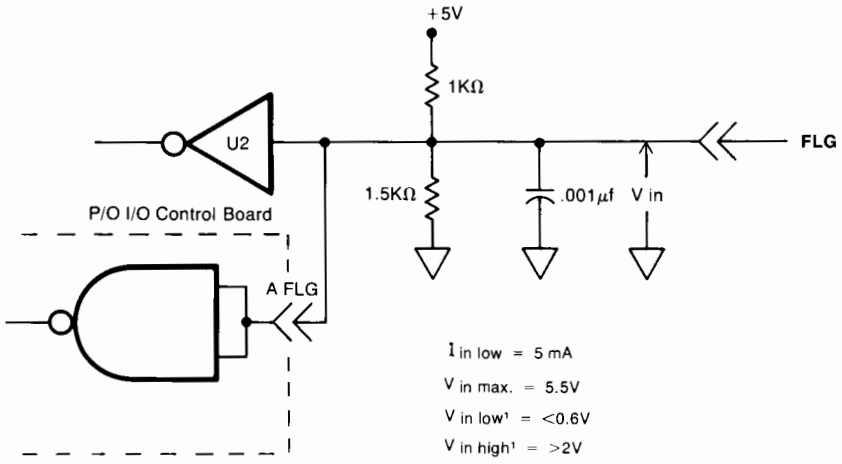
Transmitting Circuits

Each data-input line on the interface goes directly to a TTL 8-bit data latch. A resistive divider connected to each input line holds the voltage at about 3V when the cable is disconnected. The input voltage must not exceed 5.5V.



Typical Transmitting Circuits

The FLAG signal is received by a pair of TTL gates and a resistive divider as shown below. Either of the peripheral transmitting circuits just shown can be used as a flag transmitter.



Interface Flag Circuit

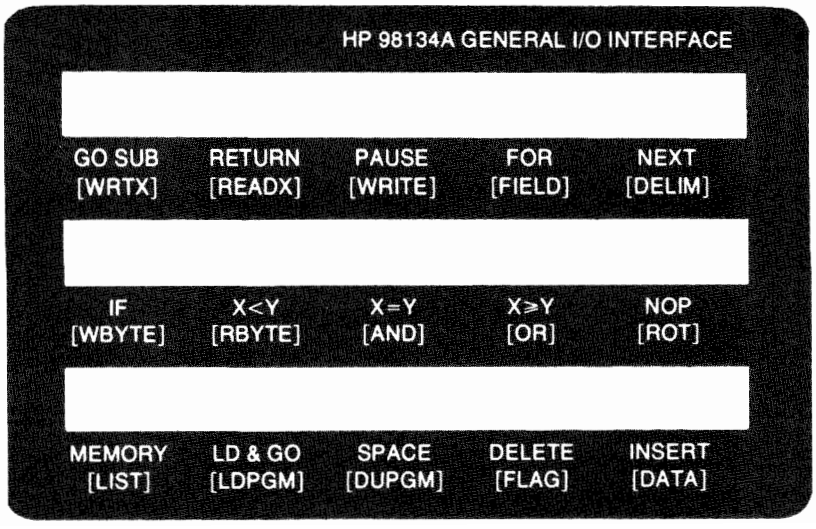
Input Data Stability

Each data character placed on the interface input lines must be settled **before** the "data ready" signal (FLG line) is transmitted. Then the data must be held stable for at least 500ns. See the "Input Timing Diagram" in Section 3.

¹When negative-true flag logic is set.

General I/O Instructions

Key Sequence	Sample Listing	Operation	Comments
[C]	0102 WRITE 2	Output the contents of the X register, followed by a CR/LF.	See page 10.
[A]	0104 WRTX 2	Same as above, but without a CR/LF.	See page 10.
[D]	0106 FIELD 2	Set data field width for WRITE and WRTX instructions.	Usable range: 1≤X≤127.
[CALL ALPHA]	0108 WRTα 2	Output ASCII-coded characters.	See table in Appendix.
[B]	0112 READX 2	Input a number to the X register.	Free-field format. See page 13.
[E]	0114 DELIM 2	Set special input delimiters for READX.	See page 15.
[F]	0116 WBYTE 2	Output an 8-bit binary byte.	Usable range: 0≤X≤255.
[G]	0118 RBYTE 2	Input an 8-bit binary byte to the X register.	Usable range: 0≤X≤255
[CALL ALPHA] [select code] followed by one key: [H]	0120 AND 2	Perform an AND logic operation using X and Y.	See page 19.
[I]	0122 OR 2	Perform an OR logic operation using X and Y.	See page 19.
[J]	0124 ROT 2	Rotate the 8-bit binary equivalent of X one place to the right.	See page 19.
[K]	LIST 2	Output formatted program listing.	See page 21.
[L]	0128 LDPGM 2	Input program into memory.	Specify first step → X.
[M]	0130 DUPGM 2	Output contents of program memory.	Specify first step → X
[N]	0132 FLAG 2	Set logic level and Handshake mode for FLG line. (Sign of X indicates logic level used.)	Disable Handshake: 0 →X Enable Handshake: 1 →X Enable Remote Mode: 2 → X
[O]	0134 DATA 2	Set negative-true or positive-true logic level for data lines.	Sign of X indicates logic level used.



2

Operation

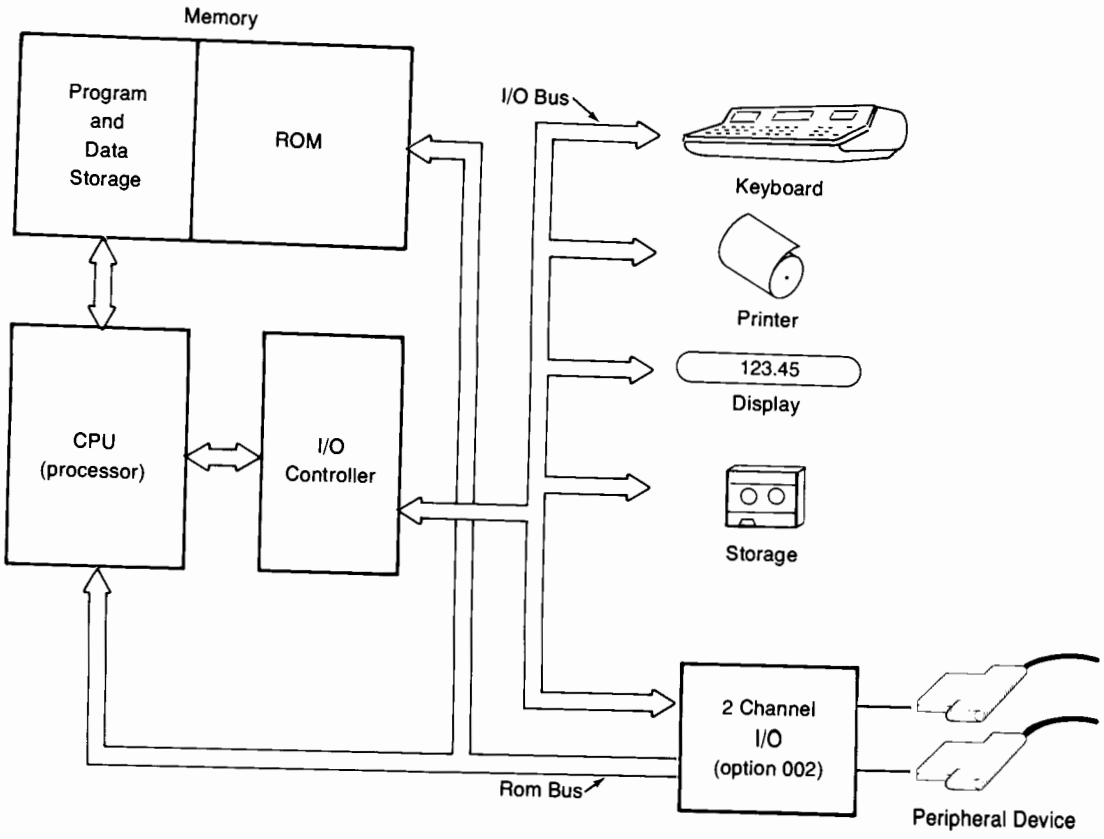
This section describes each instruction available with the General I/O Interface. If you are using the interface to control an HP 9800-series peripheral, additional operating information can be found in its accompanying Operating Note. The General I/O Instructions are summarized on the facing page. Except for LIST, all instructions are programmable.

> **NOTE**
>
> This section assumes that the reader is familiar with programming the calculator, as described in the HP 9815A Operating and Programming Manual.

A key overlay which identifies the General I/O instructions is provided with each interface (see the facing page). To use the overlay, place it over keys A through O whenever the General I/O Interface is connected.

Calculator I/O Scheme

The general I/O scheme is shown on the next page. Referring to the figure, note that each external device must be connected to the calculator via an appropriate interface, which plugs into either of the I/O channels at the back of the calculator. (The I/O channels are provided with calculator option 002.) The figure also shows that each external device shares the same I/O controller and bus (data and control lines) used by the internal devices (printer, display, etc.). The internal devices, however, do not respond to interface instructions, but only to their specific instructions (PRINT, PAUSE, etc.).



Calculator I/O Scheme

The instructions (key sequences) provided with each interface are stored in a device called a read-only-memory (ROM) within the interface. When the interface is connected and the calculator is switched on, this ROM becomes an integral part of the calculator memory. Each interface adds 2048 words of ROM.

Select Code

As mentioned in Section 1, each interface has its own select code, or address, so that you can specify the interface that responds to each I/O instruction. The select code number must be specified in each I/O instruction, as in this WRITE sequence which specifies select code 2.

CALL ALPHA 2 C

The select code is listed with each programmed I/O instruction, as shown here ▶

```
0335  •
0336 WRITE  2
0338  •
```

Input/Output Format

The I/O bus connecting the controller with internal and external peripherals contains 24 lines. Data is transmitted in an 8-bit parallel, character-serial fashion on 16 of the lines, (eight lines in and eight lines out) while the other eight lines handle calculator and interface control signals.

The WRITE and READ instructions cause the calculator to send and receive data in standard (US)ASCII code. The calculator sends or receives one 8-bit character at a time. If another character is to be sent or received, the calculator waits until the device is ready. The Binary I/O and Program I/O instructions transfer data in 8-bit binary form. A table of ASCII-binary equivalent codes is in the Appendix.

Peripheral Interrupt

Because the calculator is the controlling device in most systems, there is no provision for peripheral interrupt operation, so other devices cannot interrupt calculator operation to input or output data. The calculator must be in complete control of each device while it is involved in data transfer.

Even though hard-wired interrupt capability is not available, a "software interrupt" method can be used. (See "Remote Control" on page 21 for details.)

The DATA Instruction

CALL ALPHA · select code 0

The interface can be set to respond to either negative-true or positive-true data-logic levels, by using the DATA instruction. To set the required logic sense, set the sign of the number in X to indicate the desired level and execute the DATA instruction. The interface is automatically set to negative-true logic sense when the calculator is switched on.

A list of logic sense requirements for HP calculator peripherals is listed on the next page.

The FLAG Instruction

CALL ALPHA · select code N

The I/O control method and logic level used on the FLG line can be specified by using the FLAG instruction (I/O control is described in Section 1).

To disable the Handshake mode (ECH), enter ±0 in X and execute the FLAG instruction. To enable the Handshake mode (ECH), enter ±1 in X and execute the FLAG instruction. The Handshake mode is automatically enabled when the calculator is switched on.

The logic level used by the interface FLG line is set by the sign of the number in X. Negative-true flag logic is automatically set when the calculator is switched on.

Here is a table of DATA and FLAG settings required for HP calculator peripherals.

Peripheral	Instructions DATA	FLAG
9863A Tape Reader	*	+1
9864A Digitizer	+	−1**
9866A Thermal Printer	−**	−1**
9883A Tape Reader	*	−0
9884A Tape Punch	*	−0

*Data logic level depends on data format used.
**These are automatically set when the calculator is switched on.

WRITE Instructions

The following instructions output data and character strings to the specified device in ASCII code.

The WRITE Instruction

CALL · ALPHA · (select code) C

The WRITE instruction outputs the signs, digits and decimal point of the current number in X. The number appears, right justified, in a field of spaces and in the form set by the current number format (FIX, SCI, or SCI 3). A CR/LF (carriage return and line feed characters) is automatically output after the number. Also see "The FIELD Instruction".

If the number in X is too large to be output in a FIX format, a SCI format is automatically used.

The WRT X Instruction

CALL · ALPHA · (select code) A

The WRITE X instruction is equivalent to WRITE, except that a CR/LF is not output after the number. To output a CR, LF, or any other non-numeric character(s) use the WRT∝ (Write Alpha) instruction.

Delimiters

A delimiter is a character used to separate one number from another in a string of characters. The space (Δ) and CR/LF are delimiters automatically output with WRITE instructions. The space is used to fill the data field and the CR/LF terminates the field.

The FIELD Instruction

CALL · ALPHA · (select code) D

The data field width used for WRITE and WRTX instructions is automatically set to 16 characters when the calculator is switched on. To change the field width, enter the desired width in X and execute the FIELD instruction. The usable range is from 1 through 127. If the number to be output is too large for the currently-set field, a field of $ characters is output.

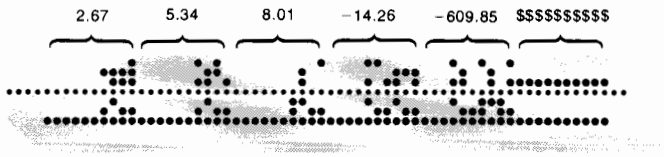
Here are some examples using WRTX and WRITE. These programs assume that the interface is set to select code 2.

The first program outputs the contents of registers 000 through 005 to an HP 9884A Tape Punch. Steps 0000 through 0004 set the number format and output field. Steps 0006 through 0009 set limits for the FOR-NEXT loop. The FOR-NEXT loop recalls, outputs and prints each number. The outputs are shown below.

```
0000 FIX    2
0002 1
0003 0
0004 FIELD  2
0006 CLX
0007 STO    A
0008 5
0009 STO    F
0010 FOR    A→F
0011 RCL I  A
0013 WRTX   2
0015 PRINT
0016 NEXT   A
0017 END
```

```
  2.67
  5.34
  8.01
-14.26
609.85
  1.00   46
```

The tape punch output shows that each number is in a 10-character field (all leading characters are spaces); "$" characters fill the last field, since the large number cannot be output within the specified format.



The next program shows how to use both WRITE and WRTX to output data in a four-column format. The output device used here is an HP 9866A Thermal Printer.

```
0000 CLX
0001 STO    A
0002 2
0003 0
0004 FIELD  2
0006 1
0007 STO+   A
0008 FIX    0
0010 RCL    A
0011 WRTX   2
0013 FIX    4
0015 SQRT
0016 WRTX   2
0018 RCL    A
0019 7
0020 Y↑X
0021 WRTX   2
0023 RCL    A
0024 1/X
0025 WRITE  2
0027 GOTO   0006
0029 END
```

Referring to the printout, notice that each number is output in a 20-character field, and that a SCI format is automatically used when the data overflows the FIX format.

20 Characters	20 Characters	20 Characters	20 Characters
1	1.0000	1.0000	1.0000
2	1.4142	128.0000	0.5000
3	1.7321	2187.0000	0.3333
4	2.0000	16384.0000	0.2500
5	2.2361	78125.0000	0.2000
6	2.4495	279936.0000	0.1667
7	2.6458	823543.0000	0.1429
8	2.8284	2.0972E+06	0.1250
9	3.0000	4.7830E+06	0.1111
10	3.1623	1.0000E+07	0.1000

The WRT∝ Instruction

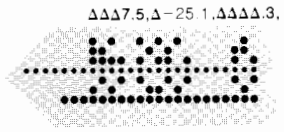
The WRITE ALPHA instruction sets an Alpha mode, similar to the internal printer's Alpha mode. Now pressing each key outputs (immediately) its corresponding ASCII character. To terminate the Alpha mode press CALL ALPHA again. A list of the available ASCII output characters is in the Appendix.

The interface provides the calculator with a "shifted" alpha keyboard, since the calculator can output more ASCII characters than there are keys on the keyboard. At the start of a WRT∝ instruction, the keyboard is in the unshifted state. Pressing ■ sets the shifted state; the keys colored light-brown in the ASCII table indicate the shifted state. To reset the unshifted state, either press ■ again or terminate the Alpha mode.

This program sequence shows how to output a series of numbers and separate each with a comma. The output device used here is an HP 9884A Tape Punch. Notice that using a PRINT instruction (step 0114) within an alpha string executes a WRTX instruction.

```
0103  ●
0104 FIX     1
0106 6
0107 FIELD   2
0109 FOR     A→F
0110 RCL I   A
0112 WRTα    2
0114 PRINT
0115 ,
0116 ENDα
0117 NEXT    A
0118  ●
```

Here is a sample output ▶



NOTE

Be sure that the Alpha mode is set when inserting or changing alpha characters. See "Editing Alpha" in Section 3 of the calculator operating manual.

READ Instruction

The following instructions input data and selected delimiter characters in 7-bit ASCII code. If 8-bit ASCII code is read, the 8th bit (most significant or parity bit) is ignored.

The READX Instruction

CALL · ALPHA · (select code) (8)

Each READX instruction inputs one data item from the specified device and places it in X. The data item can appear in a free-field format (see below), except when special delimiters are specified by a DELIM instruction.

Free-Field Format

A data item can consist of the digits 0 through 9, plus and minus signs, a decimal point, and an "E" character. All other characters are treated as input delimiters. The data item itself can assume the same form as any number which can be entered from the keyboard.

The calculator ignores all input delimiters (non-numeric characters) until one of the characters listed above is read. Then, after reading the data item, reading any non-numeric character terminates the operation.

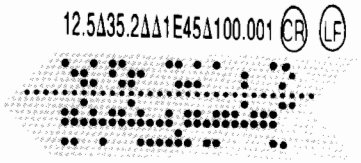
A READX is also terminated after reading "E" in any of these forms:

(data item) E (one or two digits)
(data item) E (a + or − and one or two digits)
(data item) E (a space and one or two digits)

For example, any of the following data items will be read as the number "1234":

1.234E3
1.234EΔ3
1.234E+3
123.4E+01

The following program can be used to input and print the four data items on this ASCII-coded paper tape ⧫



Referring to the program and printout, notice that each READX inputs one number to X. Each READX also automatically ENTERS the number previously in X.

The calculator reads a CR/LF character-set as one delimiter. If any other character follows CR, it will be skipped. To prevent the calculator from skipping the character following a CR, set CR as a special delimiter by using the DELIM instruction.

```
0000 CLEAR
0001 DATA    2
0003 +÷-
0004 FLAG    2
0006 READX   2
0008 READX   2
0010 READX   2
0012 READX   2
0014 FIX     3
0016 PRTSTK
0017 END
```

Here is the printout ⧫

```
  12.500
  35.200
   1.000   45
100.001
```

The DELIM Instruction

CALL · ALPHA · (select code) E

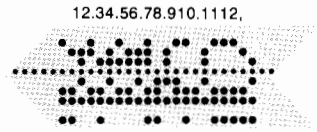
The DELIMITER instruction allows you to specify any three characters as terminating input delimiters (e.g., decimal point, digits, sign). The ASCII-decimal equivalent of each special delimiter must be in the stack as shown:

Delimiter #3 → Z
Delimiter #2 → Y
Delimiter #1 → X

When less than three special delimiters are needed, zeros must be entered into the unused registers. A table of ASCII-decimal equivalent forms is in the Appendix.

The calculator treats each special delimiter as an input delimiter. In addition, reading delimiter #1 sets program flag 4.

Here is a list of data items separated by decimal points and terminated by a comma ▶



This program uses the DELIM instruction to set the decimal point and comma as delimiters and then continually input numbers until the comma is read. The program assumes that an HP 9863A Tape Reader is used.

```
0000 1
0001 +÷-
0002 FLAG    2
0004 CLEAR
0005 DATA    2
0007 CFG     4
0008 4
0009 6
0010 ENTER↑
0011 4
0012 4
0013 DELIM   2
0015 READX   2
0017 PRINT
0018 IF CFG 4
0019 GOTO    0015
0021 SPACE
0022 SPACE
0023 SPACE
0024 SPACE
0025 END
```

Here is the printout ▶

```
          12
          34
          56
          78
         910
        1112
```

Binary Instructions

The WBYTE Instruction

CALL ALPHA · (select code) F

The WRITE BYTE instruction outputs the 8-bit binary equivalent of the integer value in X. The number can be from 0 to 255. The error message ILLEGAL ARGUMENT indicates a number outside the range. A table of decimal and binary-equivalent numbers is in the Appendix.

For example, to output an ASCII "BELL" character (decimal 7) between numbers, this program sequence could be used ▶

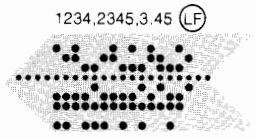
```
0098  •
0099 RCL I   A
0101 WRTX    2
0103 7
0104 WBYTE   2
0106 1
0107 STO+    A
0108 GOTO    0099
0110  •
```

The RBYTE Instruction

CALL ALPHA · (select code) G

The READ BYTE instruction inputs one 8-bit binary character from the specified device and places its decimal-equivalent number in X. The range is from 0 through 255.

For example, to read this ASCII-coded paper tape using an HP 9883A Tape Reader ▶ run the program shown below.



Step 0007 checks for a LF character; the program runs until one is found.

```
0000 FIX     0
0002 RBYTE   2
0004 PRINT
0005 1
0006 0
0007 IF X=Y
0008 GOTO    0012
0010 GOTO    0002
0012 END
```

Here is the printout ⧫

Compare the list of decimal numbers with the ASCII characters listed in the Appendix.

```
49
50
51
52
44
50
51
52
53
44
51
46
52
53
10
```

Code Conversion

The method shown in the next program can be used to input data coded in a form other than ASCII. This program inputs integer data punched in EIA[1] code (see the table) and converts each character to the decimal value before combining the digits and storing the number. The program assumes that the data consists of only the digits 0 through 9, that each item is followed by a comma, and that the tape is terminated by a CR. Here is a list of usable characters:

Binary	Character	EIA Decimal Equivalent
00100000	0	32
00000001	1	1
00000010	2	2
00010011	3	19
00000100	4	4
00010101	5	21
00010110	6	22
00000111	7	7
00001000	8	8
00011001	9	25
00111011	Comma	59
10000000	Carr Ret	128

[1]EIA is an 8-bit code adopted by the Electronic Industries Association.

```
0000 CLEAR
0001 CLRA→J
0002 3
0003 3
0004 STO     C
0005 4
0006 7
0007 #REGS
0008 CLX
0009 STO     R032
0011 1
0012 STO     R001
0014 2
0015 STO     R002
0017 3
0018 STO     R019
0020 4
0021 STO     R004
0023 5
0024 STO     R021
0026 6
0027 STO     R022
0029 7
0030 STO     R007
0032 8
0033 STO     R008
0035 9
0036 STO     R025
0038 CLX
0039 RBYTE   2
0041 STO     A
0042 5
0043 9
0044 IF X=Y
0045 GOTO    0049
0047 GOTO    0058
0049 RCL     B
0050 STO I   C
0052 1
0053 STO+    C
0054 CLX
0055 STO     B
0056 GOTO    0039
0058 RCL     A
0059 1
0060 2
0061 8
0062 IF X=Y
0063 GOTO    0073
0065 1
0066 0
0067 STO*    B
0068 RCL I   A
0070 STO+    B
0071 GOTO    0039
0073 FIX     0
0075 RCL     C
0076 3
0077 3
0078 STO     A
0079 X≠Y
0080 STO     F
0081 FOR     A→F
0082 RCL I   A
0084 PRINT
0085 NEXT    A
0086 SPACE
0087 SPACE
0088 SPACE
0089 SPACE
0090 END
```

A summary of the program:

- Steps 0008 - 36 initialize a code-conversion array, with each "EIA-numbered" register containing an ASCII-decimal equivalent number.
- Steps 0039 - 41 input and store one character from the tape reader.
- Steps 0042 - 55 store any previously-read data in a numbered register if the character is a comma.
- Steps 0058 - 63 exit the input routine if the character is a CR.
- Steps 0065 - 70 combine the digit with the previously-read data in register B.
- Steps 0081 - 84 are a FOR-NEXT loop which prints the data, as read from the tape.

The AND Instruction

CALL ALPHA select code H

This instruction combines the binary equivalents of X and Y in an AND logic operation (i.e., X•Y). The result is placed in X and the other numbers in the stack are dropped down (as with arithmetic operations). The usable range is from 0 through 255.

During an AND, the numbers in X and Y are first converted to 8-bit binary numbers. Then each X-bit is compared with its corresponding Y-bit; if both are 1, the resulting X-bit is 1. But if either bit is 0, then the resulting X-bit is 0. Finally, the result is converted to decimal and the other stack contents are dropped down.

For example, if: 25→Y (00011001)
37→X (00100101)
The AND gives: 1→X (00000001)

The OR Instruction

CALL ALPHA select code I

This instruction combines the 8-bit binary equivalents of X and Y in an inclusive OR logic operation (i.e., X+Y). The result is placed in X and the other numbers in the stack are dropped down (as with arithmetic operations). The usable range is from 0 through 255.

During an OR operation, each X-bit is compared with its corresponding Y-bit. If either bit is 1, the resulting X-bit is 1. But if both bits are 0, the resulting X-bit is 0.

For example, if: 89→Y (01011001)
45→X (00101101)
The OR gives: 125→X (01111101)

The ROT Instruction

CALL ALPHA select code J

The ROTATE instruction rotates the bit values of the 8-bit binary equivalent of X one place to the right. The result is left in X (in decimal), while the other stack contents are unaffected.

For example, if: 133→X (10000101)
The ROT gives: 194→X (11000010)

Here's a program sequence that inputs 8-bit characters from a paper tape reader, separates each character into two 4-bit bytes and then prints the decimal equivalent of each byte. The program halts when an ASCII "LF" (decimal 10) is seen.

```
0297  ●
0298 RBYTE   2
0300 ENTER↑
0301 ENTER↑
0302 1
0303 0
0304 IF X=Y
0305 GOTO    0330
0307 ROLL↓
0308 1
0309 5
0310 AND     2
0312 PRINT
0313 ROLL↓
0314 ROT     2
0316 ROT     2
0318 ROT     2
0320 ROT     2
0322 1
0323 5
0324 AND     2
0326 PRINT
0327 SPACE
0328 GOTO    0298
0330 STOP
0331  ●
```

Calculate and print least-significant byte.

Calculate and print most-significant byte.

Program Instructions

These instructions enable programs to be transferred between a peripheral and the calculator memory. The DUMP PROGRAM and LOAD PROGRAM instructions transfer program steps in an 8-bit binary code. The LIST instruction outputs a formatted, ASCII-coded program listing to the specified device.

The DUPGM Instruction

(CALL ALPHA) (select code) (M)

The DUMP PROGRAM instruction outputs the contents of the program memory, starting at the step address indicated in X and stopping after an END has been output. This allows you to rapidly record a program on, say, a punched tape.

The LDPGM Instruction

CALL ALPHA select code L

The LOAD PROGRAM instruction inputs previously "dumped" program steps into the program memory, starting at the step address indicated in X and continuing until an END has been loaded. When this instruction is given from a program, the calculator executes the step following LDPGM after the new program has been loaded.

The LIST Instruction

CALL ALPHA select code K

This instruction outputs a program listing, starting at the current step address and stopping after an END is output. The listing is formatted into four, 50-step columns for use with a page-wide line printer. A sample is shown on the following pages. The listing stops after each 200 steps for the operator to load more paper. To continue the listing, press K again.

The LIST instruction is not programmable.

Remote Control

When the calculator is in the "Remote" mode, it waits at each I/O instruction for the peripheral to begin the operation. To set the Remote mode, enter ±2 in X and execute a FLAG instruction:

CALL ALPHA select code N

Normally, with or without the Handshake mode enabled, the calculator begins each I/O operation and then waits for the peripheral to respond and indicate "done" by forcing the FLG line to a logical 1 state. This means that the peripheral must always be waiting for calculator instructions. When the Remote mode is set, however, the calculator waits at each I/O instruction for the peripheral to begin the operation by forcing the FLG line to a logical 1 state.

An example use for the Remote mode would be where one calculator is needed for accumulating (gathering) data, while a second calculator could be used at the same time to reduce the data (use it in computations). Both calculators would be connected via General I/O Interfaces and the "data accumulator" would be set to the Remote mode whenever it's ready to transfer data to the "controller". This "two-processor" arrangement, with one calculator controlling the I/O operations between them, offers an extremely fast and flexible system for acquiring and compiling data.

Sample Program Listing

```
0000 1
0001 CHS
0002 FLAG    2
****
0004 DATA    2
****
0006 1
0007 3
0008 FIELD   2
****
0010 1
0011 STO     A
0012 STO     C
0013 STO     D
0014 1
0015 0
0016 STO     H
0017 WRT@    2
****
0019 LINE
0020 LINE
0021 LINE
0022 END@
0023 1
0024 6
0025 GOSUB   L
****
0027 WRT@    2
****
0029 -
0029 -
0031 -
0032 H
0033 .
0034 P
0035 .
0036
0037 9
0038 8
0039 6
0040 6
0041 A
0042
0043 T
0044 H
0045 E
0046 R
0047 M
0048 A
0049 L
0050
0051 P
0052 R
0053 I
0054 N
0055 T
0056 E
0057 R
0058
0059 P
0060 R
0061 O
0062 G
0063 R
0064 A
0065 M
0066
0067 E
0068 X
0069 A
0070 M
0071 P
0072 L
0073 E
0074 -
0075 -
0076 -
0077 LINE
0078 LINE
0079 LINE
0080 END@
0081 2
0082 5
0083 GOSUB   L
****
0085 WRT@    2
****
0087 2
0088 END@
0089 1
0090 2
0091 GOSUB   L
****
0093 WRT@    2
****
0095 3
0096
0097
0098
0099
0100
0101 -
0102 -
0103 -
0104 -
0105 S
0106 O
0107 U
0108 A
0109 R
0110 E
0111
0112
0113 R
0114 O
0115 O
0116 T
0117 S
0118 -
0119 -
0120 -
0121 -
0122
0123
0124
0125
0126 C
0127 U
0128 B
0129 E
0130
0131 R
0132 O
0133 O
0134 T
0135 S
0136 LINE
0137 END@
0138 1
0139 2
0140 GOSUB   L
****
0142 WRT@    2
****
0144 N
0145 END@
0146 1
0147 1
0148 GOSUB   L
****
0150 WRT@    2
****
0152 N
0153 END@
0154 1
0155 2
0156 GOSUB   L
****
0158 WRT@    2
****
0160 N
0161 END@
0162 1
0163 0
0164 GOSUB   L
****
0166 WRT@    2
****
0168 N
0169 END@
0170 1
0171 1
0172 GOSUB   L
****
0174 WRT@    2
****
0176 1
0177 0
0178 N
0179 END@
0180 1
0181 1
0182 GOSUB   L
****
0184 WRT@    2
****
0186 N
0187 LINE
0188 LINE
0189 END@
0190 1
0191 0
0192 STO     F
0193 FOR     A-F
0194 FOR     C-HD
0195 FIX     0
****
0197 RCL     C
0198 WRTX    2
****
```

```
0200 ENTER↑          0250
0201 ENTER↑          0251 END@
0202 *               0252 NEXT    A
0203 WRTX    2       0253 1
****                 0254 STO     A
0205 *               0255 RETURN
0206 WRTX    2       0256 END
****
0208 FIX     6
****
0210 RCL     C
0211 SQRT
0212 WRTX    2
****
0214 RCL     C
0215 1
0216 0
0217 *
0218 SQRT
0219 WRTX    2
****
0221 RCL     C
0222 3
0223 1/X
0224 Y↑X
0225 WRITE   2
****
0227 NEXT    C
0228 WRT@    2
****
0230 LINE
0231 END@
0232 1
0233 0
0234 STO+    H
0235 NEXT    A
0236 WRT@    2
****
0238 LINE
0239 LINE
0240 LINE
0241 END@
0242 GOTO    0256
****
0244 LBL
---- L
0246 STO     F
0247 FOR     A-F
0248 WRT@    2
****
```

3

Service

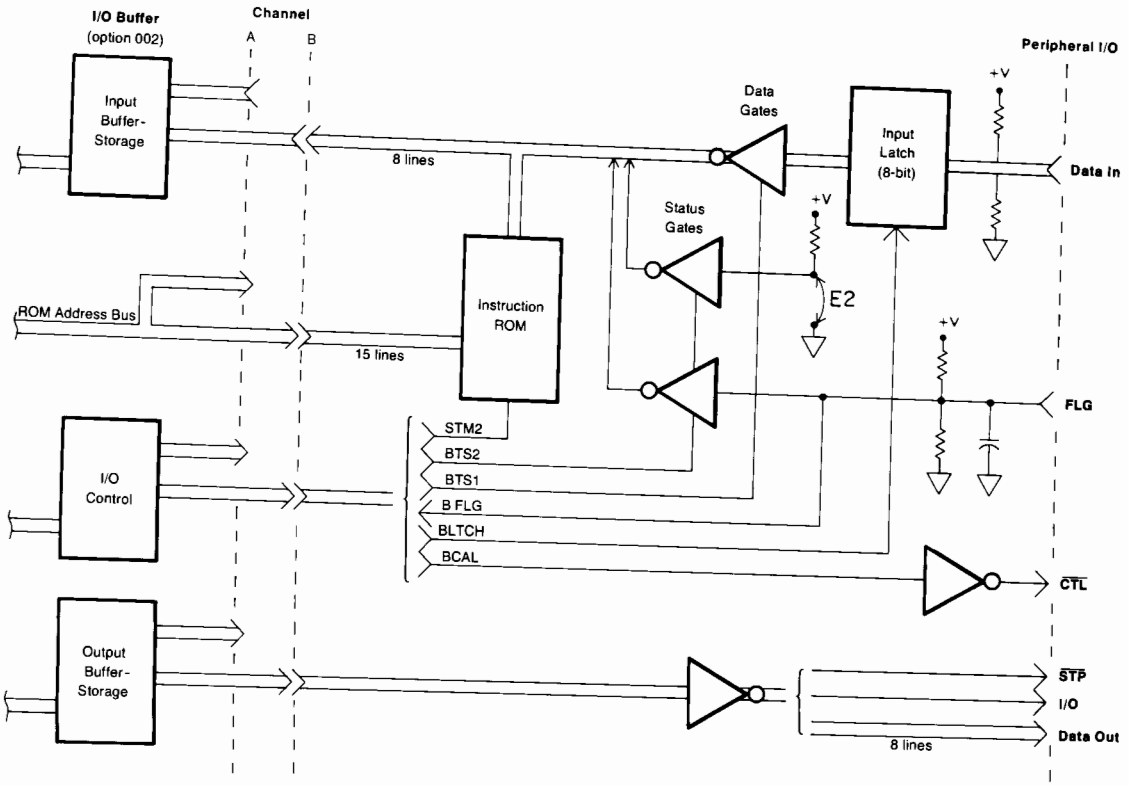
This section contains a brief description of interface operation, and instructions to help you repair the interface. A complete circuit diagram and a list of replaceable parts are at the back of this section.

If you have difficulty repairing the interface or if you would rather have HP repair it, contact the nearest sales and service office for assistance; office locations are listed after the circuit diagram.

When ordering a replacement circuit board, specify HP Part No. 98134-69503.

Theory of Operation

A block diagram of the interface is shown on the next page. The interface circuit board contains an instruction ROM, an input-data latch, data buffers, and interface status circuits. Notice in the diagram that data buffer-storage and most of the I/O control circuits are on the I/O Buffer, which is calculator option 002. The I/O Buffer also provides separate data and control lines for each I/O channel, allowing the calculator to select the channel used for each operation.



Interface Block Diagram

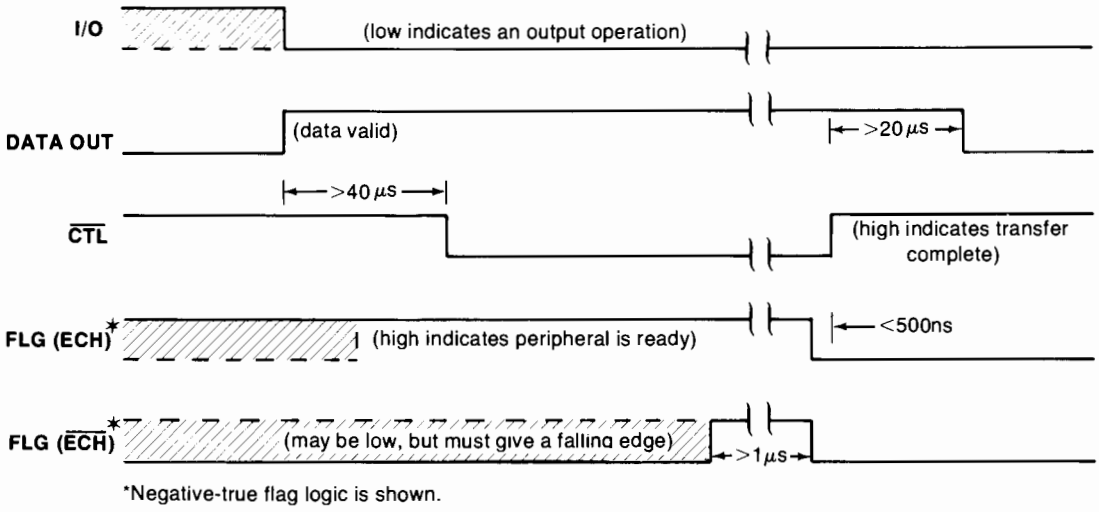
As shown in the block diagram, input data, interface status, and ROM information are transmitted to the calculator on the same Data In Lines. Control signals BTS1, BTS2, and STM2 determine which information is currently being transmitted.

The interface select code is determined by the position of programming plug E2. The interface responds to either select code 2 when the plug is in place, or select code 3 when the plug is removed (in its alternate position).

Data Output Sequence (see timing diagram)

This sequence occurs for each data character output:

1. As an output instruction is executed from the calculator, the status gates are enabled.
2. The calculator checks interface status on the FLG line. If the interface is not busy, data is placed on the Data Out lines and the I/O line goes low to indicate that an output operation has started. About 40μs later the $\overline{\text{CTL}}$ line is forced low.
3. Data is held on the output lines until the peripheral indicates "done" by sending a FLG signal. Then, another character is placed on the Data Out lines (returns to step 2).

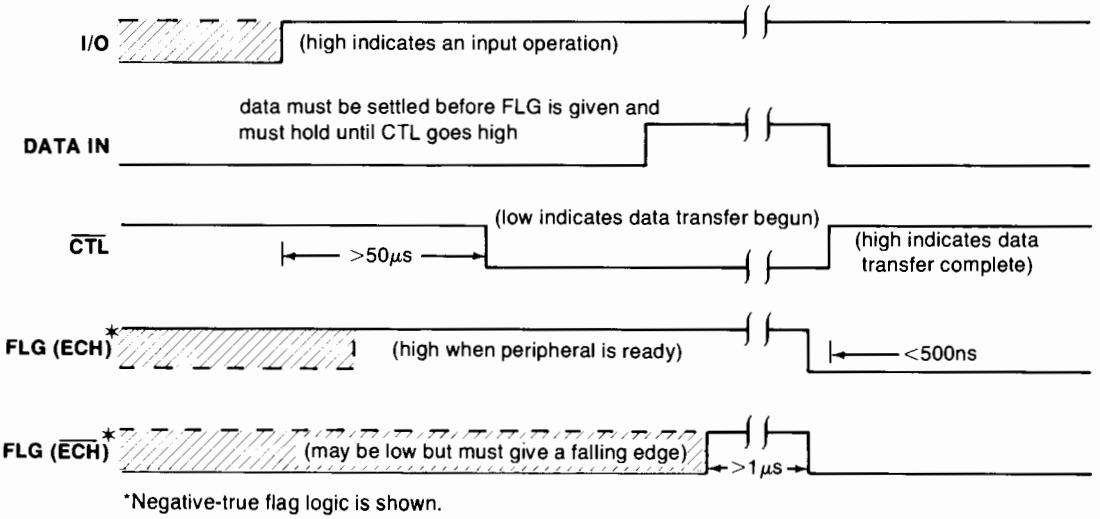


Output Timing Diagram

Data Input Sequence (see timing diagram)

This sequence occurs for each data-character input:

1. As an input instruction is executed, the status gates are enabled.
2. If the interface is not busy (FLG status), the I/O line is forced high to indicate that an input has begun. About 50μs later $\overline{CTL}$ goes low, indicating that the calculator is ready. Now the calculator waits for the peripheral to place data on the Data In lines and indicate "ready" via the FLG line.
3. About 500ns after the FLG signal is sent, the calculator enables the Data Latch and the Data Gates, transferring the data character to the I/O Buffer. Then $\overline{CTL}$ is forced high and the gates and latch are disabled.
4. If another character is to be input, the sequence returns to step 2.

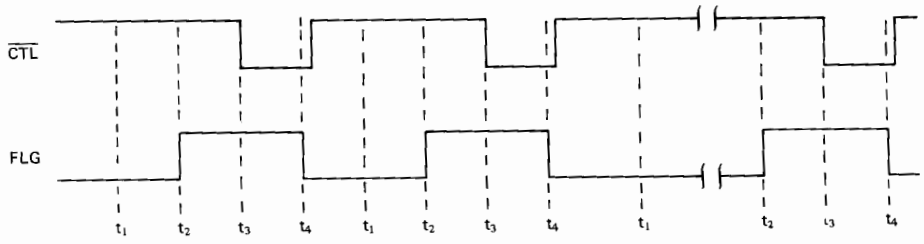


Input Timing Diagram

The Handshake Mode

The FLAG instruction[1] permits the use of an alternate I/O control method called "the Handshake mode". When the mode is set, the calculator checks for a logical 0 on the FLG line before continuing the I/O Operation. Whenever FLG is found to be 1, the calculator waits until the peripheral changes the FLG state to 0.

The diagram below shows the handshake interaction between the $\overline{CTL}$ and FLG lines (negative-true flag logic is shown here).



t_1 = peripheral holds interface "busy" by holding FLG low.

t_2 = peripheral forces FLG high to continue I/O operation.

t_3 = calculator forces $\overline{CTL}$ low to indicate either "ready to accept data" or "output data is valid".

t_4 = peripheral forces FLG low to indicate either "data ready" or "data accepted". Calculator will again wait until FLG is returned high.

Handshake Mode Timing Diagram

Additional Theory

Refer to the fold-out circuit diagram while reading the following sections.

ROM Enable

U8 is a BCD-to-decimal decoder which, together with its associated circuitry, enables the ROM as each I/O instruction is executed. The signals on the ROM address bus are strobed continuously and have no steady state.

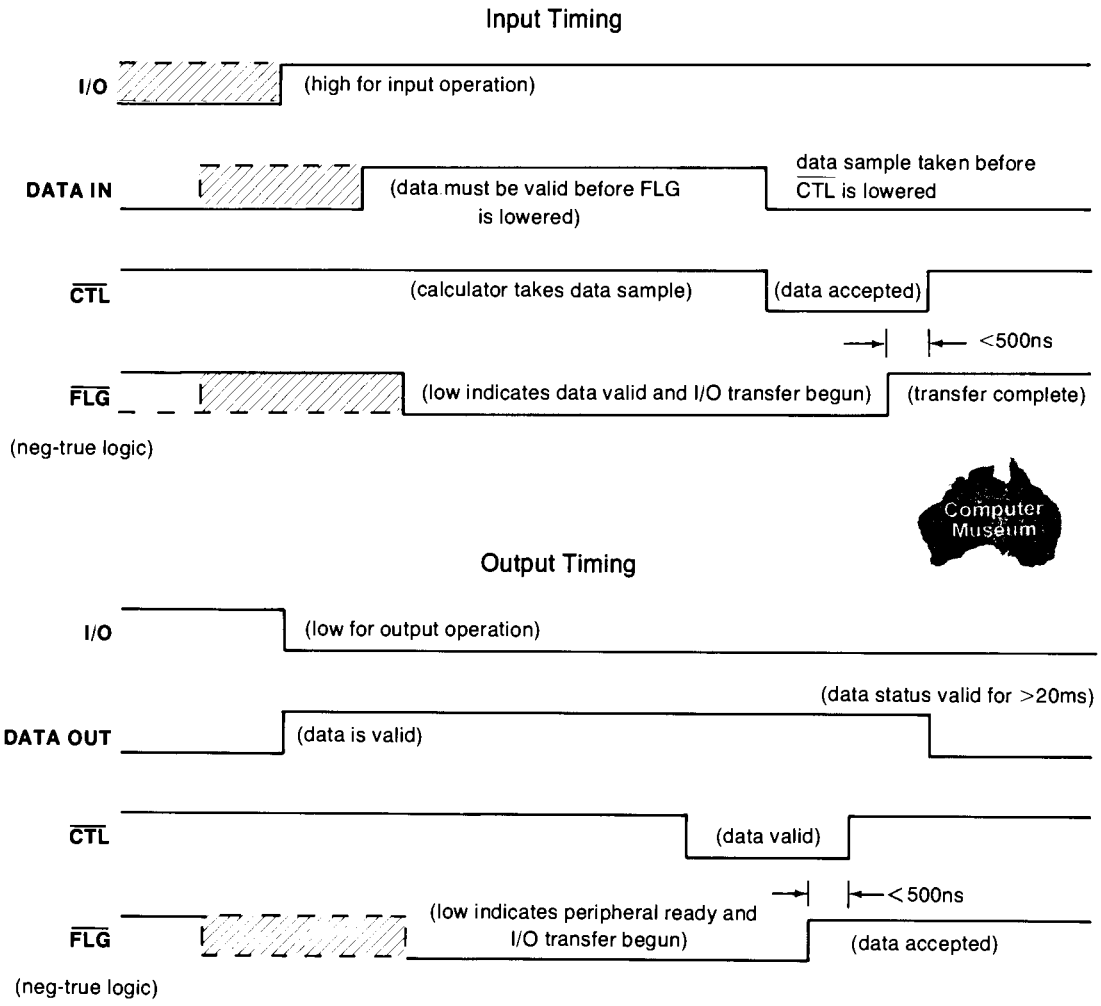
ROM Power-up

Q1 controls the −12V supply for U7. Q1 is switched off except when the ROM is enabled by an I/O instruction. C1 enables Q1 to switch-on more rapidly.

[1]The FLAG instruction is described in Section 2.

Remote Mode Timing

After a FLAG instruction has enabled the Remote mode (see Section 2), the calculator waits at each output or input instruction for the peripheral to force the FLG line to a logical 1. Then the calculator forces the $\overline{CTL}$ line low and executes the I/O operation. Timing diagrams are shown below.



Remote Mode Timing Diagrams

Troubleshooting & Repair

Read the following paragraphs before attempting to service the interface. When you suspect that the interface is defective, first disconnect it from the calculator and verify calculator operation by running all applicable tests using the Utility and Test Cartridge. See Appendix 2 of the calculator operating manual for instructions.

Broken Trace Repair

If any internal trace on the circuit board is open or has high resistance, it should be bridged using insulated wire, on the back of the board.

> **CAUTION**
> To help prevent damage to the circuit board, use a low-temperature soldering iron when replacing parts.

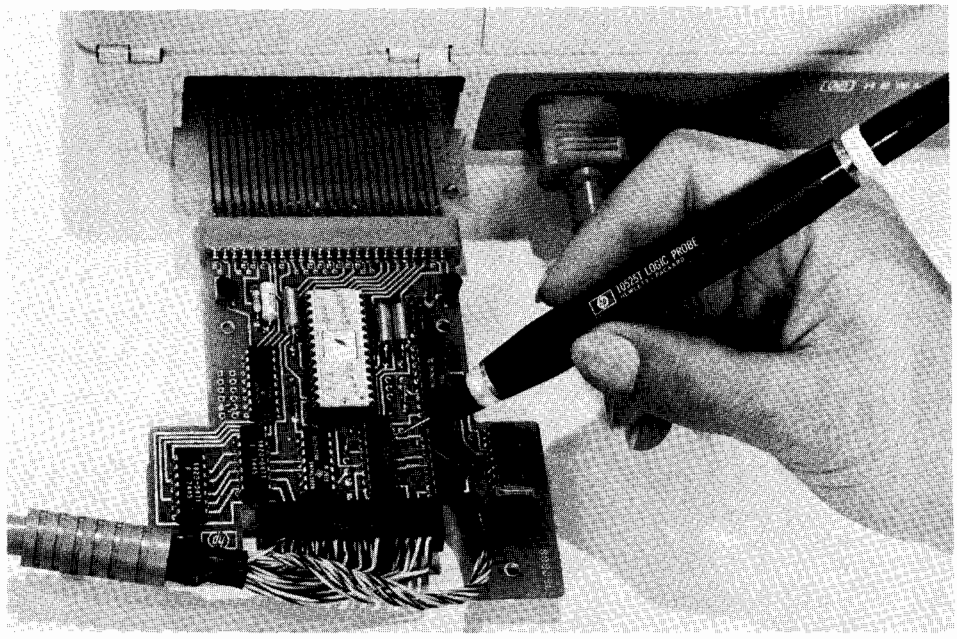
Equipment Required

- An HP 9815A Calculator, with option 002 (two-channel I/O).
- An HP 10525A Logic Probe (or equivalent) with an appropriate power supply.
- An HP 427A Voltmeter (or equivalent).
- A board extender card, HP Part Number 09815-66582.

Test Setup

Switch the calculator off and disconnect all interfaces. Remove the interface circuit board from its case and connect it to the calculator, using the board extender (see the next photo). Be sure that the circuit board is connected with the component side **up**, as shown in the photo.

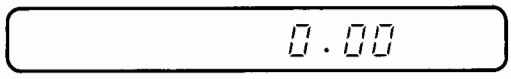
Before switching the calculator on, first verify that the select code plug is in position for select code 2 (see page 4). Then check for broken wires on the interface cable connector; refer to the connector wiring diagram on page 35.



Troubleshooting the Interface

Power-Up Check

1. Switch the calculator on.



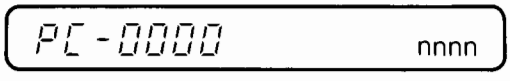
2. If the display shown above does not appear, switch the calculator off, disconnect the circuit board and switch the calculator back on.
3. If the correct display appears when the interface is **not** connected, but does not appear when the interface **is** connected (try each I/O channel), disconnect the circuit board and check for a shorted or low-resistance line on each calculator-to-interface pin. Use the negative lead of C4 as a ground reference (see page 34). All pins should measure greater than 1MΩ to ground except these (±10 % tolerance allowed):

   A1 = 1KΩ
   A19, 20 = 200Ω
   A21, 22, 23 = 0Ω
   A25 = 4 to 5KΩ

   B1 = 26KΩ
   B25 = 700Ω

   If an incorrect measurement is found, check the related components and circuit-board traces. Then reconnect the interface to the calculator and repeat step 1.

4. Set 



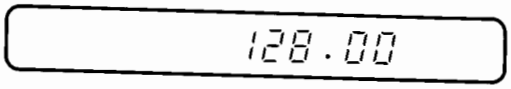
   The number displayed on the right should be either 0384 (basic memory) or 1920 (option 001). If not, perform the ROM check procedure.

ROM Check

This procedure verifies U3, U7, U8, and Q1.

1. Set 

Press (1) (CALL ALPHA) (2) (J)



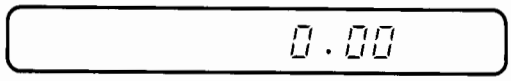
2. If the busy display stays on, press (RUN STOP). If pressing (RUN STOP) does not cancel the busy display, the calculator is defective. Contact an HP sales office for assistance.
3. If a number other than 128.00 is returned, monitor U7 pin 15 and press the sequence again. A negative pulse should be seen each time the sequence is executed. If not, replace U3 or U8.
4. Monitor U7 pin 13. A positive pulse should be seen each time the sequence is executed. If not, check Q1 and its related components.
5. If pulses are seen at U7 pins 13 and 15 (steps 3 and 4), but the key sequence does not return 128.00, replace U7.

Output Data Check

This procedure verifies U4, U5, Q2, and part of U2.

1. Connect a jumper wire from pin H to pin J on the cable connector.
2. Set 

Press (CLEAR) (CALL ALPHA) (2) (F)



If the busy display remains on, press (RUN STOP) and go to step 5.

3. Now check each of the Data Out lines (OØ-O7). Each line should be low. If not, check its corresponding inverter, U4 or U5. Then repeat this step.

   If any of the calculator-to-interface output lines (ADØ-AD7) remain high, the calculator I/O Buffer is defective.
4. Go to the "Input Data Check".
5. Check for a CTL pulse at each of the pins listed below; press this sequence for each check:
   (CLEAR) (CALL ALPHA) (2) (F) (press (RUN STOP), if needed, to cancel the busy display).
   If a pulse is not seen, replace the indicated component(s).
6. Return to step 2.

Monitor:	Check:
pin L	(Calculator requires service)
pin J	Q2, R5, R1
pin H	Test jumper wire (see step 1)
U2 pin 7	U2, C5, R1

Input Data Check

This procedure verifies U1, U2, U6, and R1.

1. Connect a jumper wire from pin H to pin J. Connect a second jumper to pin E (ground); leave the other end free.
2. Set 

   Press [CLEAR] [+/-] [CALL ALPHA] [2] [N] [CALL ALPHA] [2] [O]
3. Press [1] [CALL ALPHA] [2] [G]

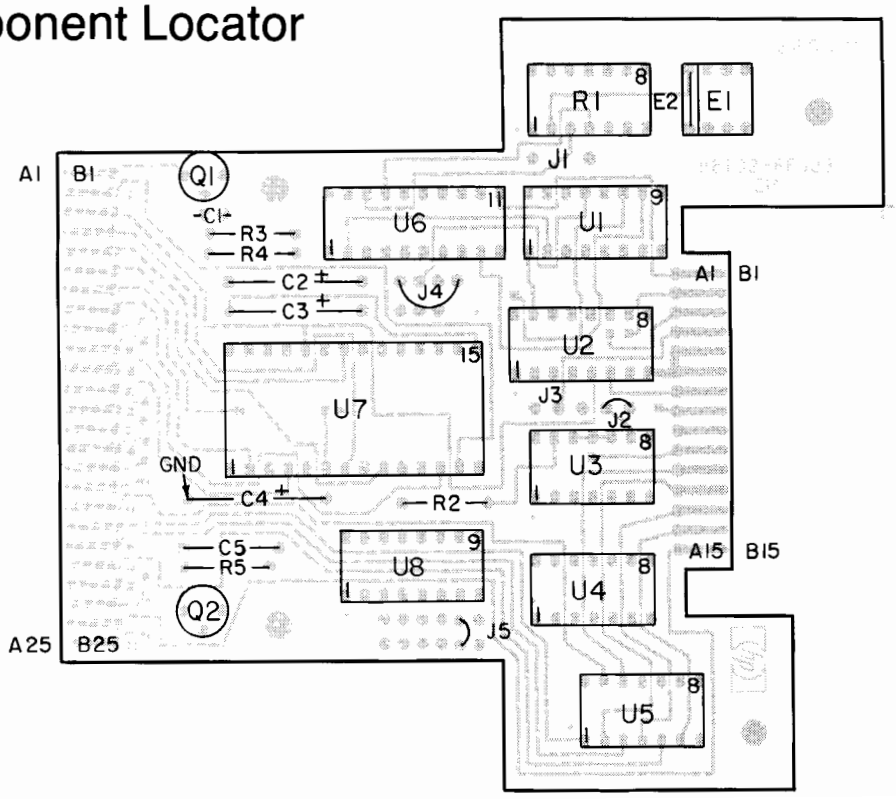
4. If any other number is displayed, check U6, U1, and U2. If one of the Data In lines (IØ-I7) is low, also check R1.
5. If the busy display remains on after the key sequence has been pressed, press [RUN STOP] and check the CTL-FLG circuits as described in step 5 of the Output Data Check. Then repeat step 2 of this procedure.
6. Connect the unused end of the jumper wire at pin E to each pin listed below and press [CALL ALPHA] [2] [G] . If the indicated display is not obtained, check U6, U1, and U2.

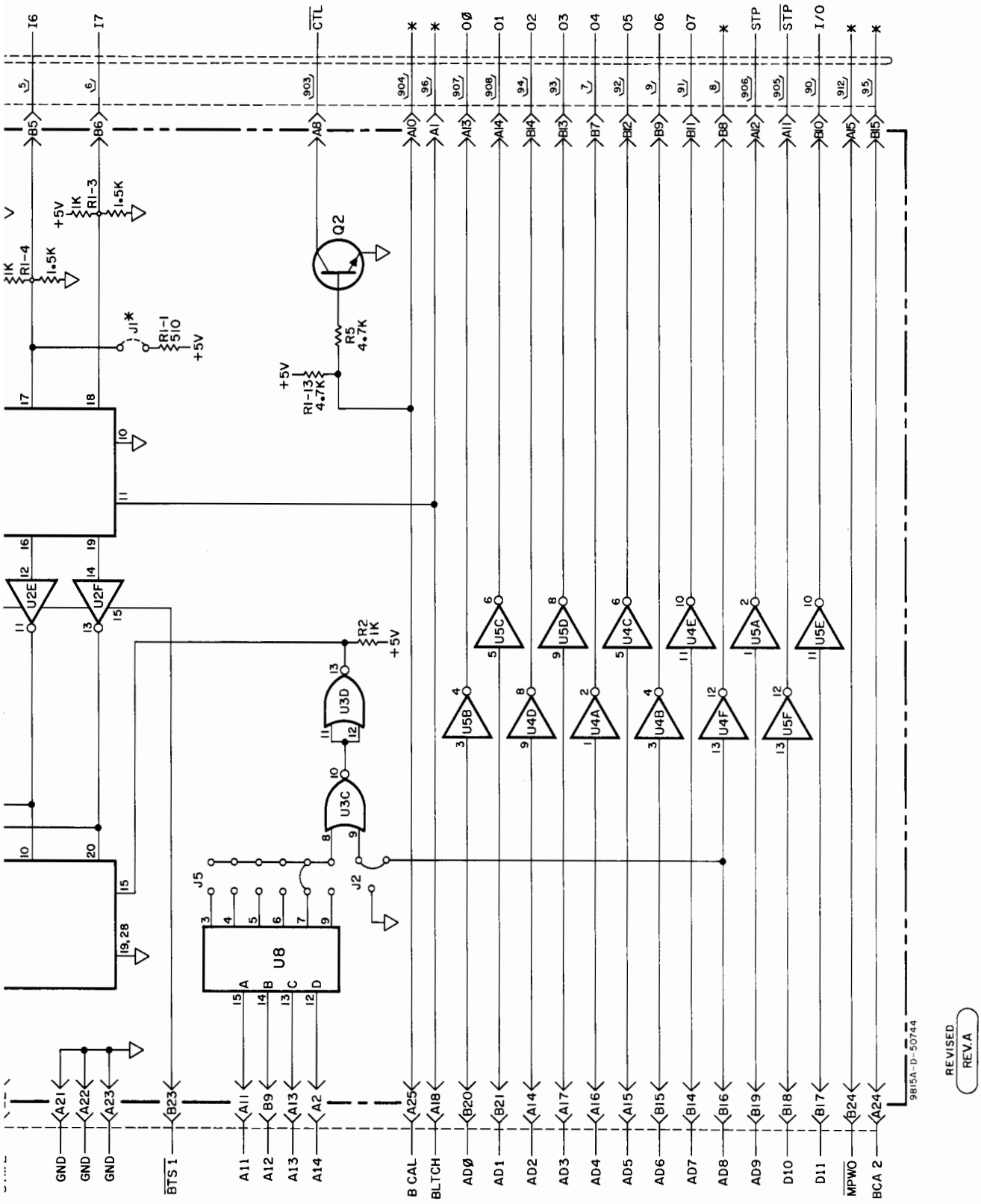
Ground Pin:	Display:
6	128.00
5	64.00
C	32.00
B	16.00
1	8.00
2	4.00
3	2.00
4	1.00

Replaceable Parts

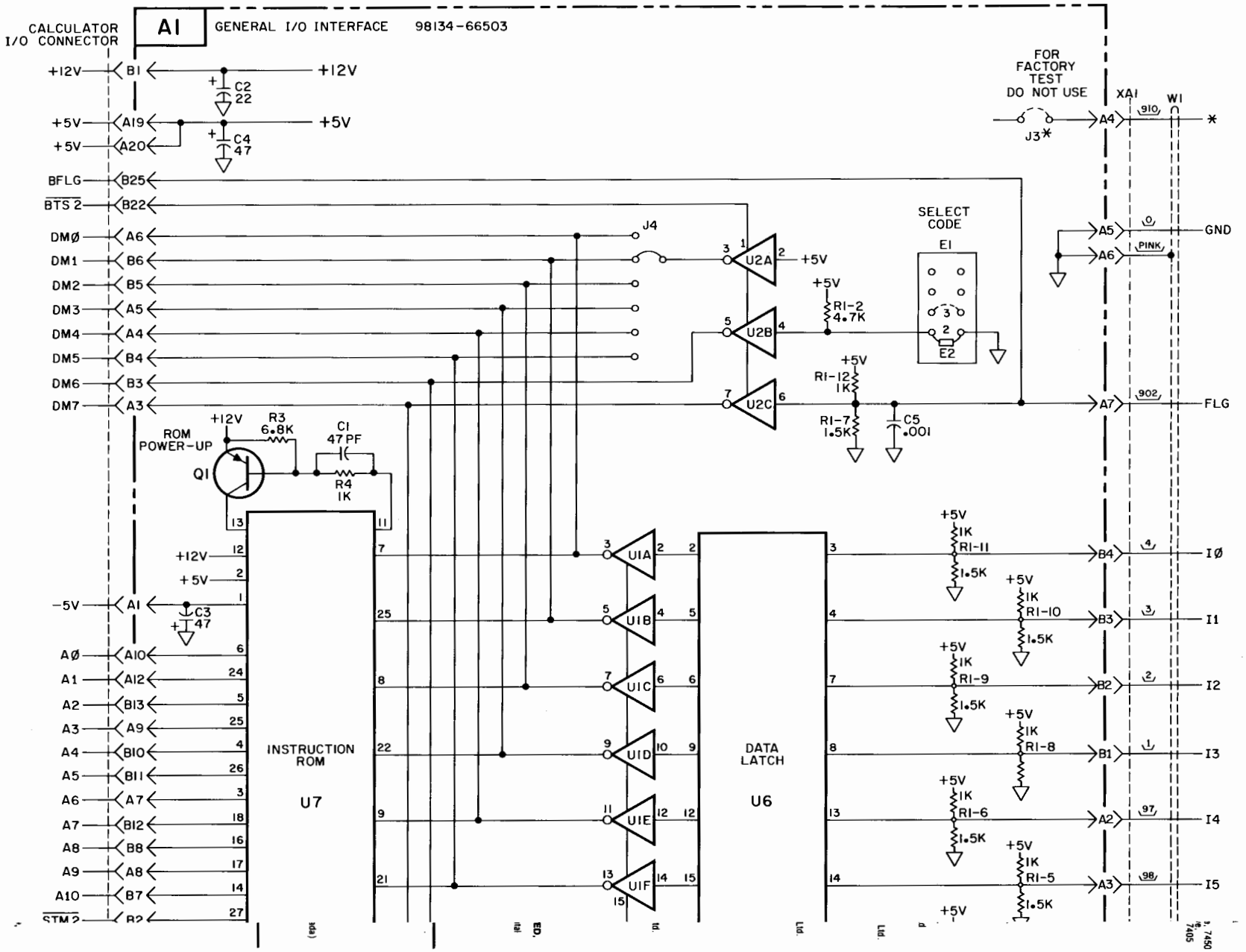
REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION
A1	98134-69503		1	P.C. Assembly
C1	0160-4345		1	Cap: 47pf, 100V
C2	0180-0228		1	Cap: 22 μf, 15V
C3,C4	0180-1704		2	Cap: 47 μf, 6V
C5	0160-0153		1	Cap: .001 μf, 200V
E1	1200-0471		1	Socket: 8-pin DIP
E2	1258-0124		1	Plug, select code
Q1	1853-0058		1	Transistor: Si., PNP
Q2	1854-0071		1	Transistor: Si., NPN
R1	1810-0230		1	R-Network: 16-pin DIP
R2,R4	0683-1025		2	Res: 1K,1/4W,5%
R3	0683-6825		1	Res: 6.8K,1/4W,5%
R5	0683-4725		1	Res: 4.7K,1/4W,5%
U1,U2	1820-1255		2	IC: Hex Inverter, DM8098N
U3	1820-1144		1	IC: Quad, 2-input NOR gate, SN74LS02N
U4,U5	1820-0471		2	IC: Hex Inverter/Driver, SN7406N
U6	1820-1461		1	IC: 8-bit Latch, SN74273N
U7	1818-2627		1	IC: ROM
U8	1820-1418		1	IC: Decoder, SN74LS42J
W1	98134-61603		1	Cable Assembly w/connector
	1251-2171		1	Connector, 30 pin
	5040-7781		1	Cover, Top
	5040-7782		1	Cover, Bottom
	98134-90000		1	Operating & Service Manual
	7120-5091		1	Key Overlay

Component Locator

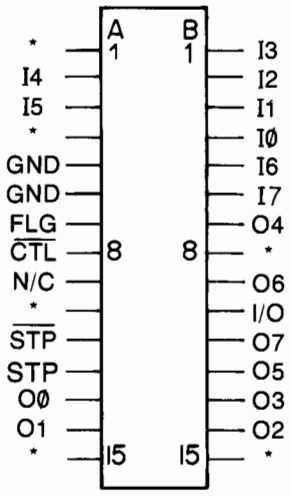




98134A Circuit Diagram


CALCULATOR I/O CONNECTOR
A1
GENERAL I/O INTERFACE 98134-66503
FOR FACTORY TEST DO NOT USE
J3*
XA1
W1
+12V
+5V
BFLG
BTS 2
DMØ
DM1
DM2
DM3
DM4
DM5
DM6
DM7
-5V
AØ
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
C2 22
C4 47
C3 47
J4
U2A
U2B
U2C
SELECT CODE
E1
E2
R1-2 4.7K
R1-12 1K
R1-7 1.5K
C5 .001
ROM POWER-UP
Q1
R3 6.8K
C1 47PF
R4 1K
INSTRUCTION ROM
U7
U1A
U1B
U1C
U1D
U1E
U1F
DATA LATCH
U6
R1-11 1.5K
R1-10 1.5K
R1-9 1.5K
R1-8
R1-6 1.5K
R1-5 1.5K
GND
FLG
I0
I1
I2
I3
I4
I5

XA1 Connector



(Back View)

Schematic Notes:

1. Unless indicated otherwise, resistor values are shown in ohms and capacitor values are shown in microfarads.
2. Jumper wires J1 and J3 and the output lines indicated by an * are not used on the General I/O Interface. See the HP 9815A Service Manual for other applications of the circuit board.
3. See page 3 before changing the position of E2, the select code plug.
4. Wire color code is the same as resistor color code: The first number indicates the base color, second number indicates the wider strip, and third color indicates the narrower strip (e.g., 924 = white, red, yellow).

0 = Black	5 = Green
1 = Brown	6 = Blue
2 = Red	7 = Violet
3 = Orange	8 = Grey
4 = Yellow	9 = White

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Appendix

Binary Coding and Conversions

Binary is a base 2 number system using only 1's and 0's. By giving the 1's and 0's positional value, any decimal number can be represented. For example, this diagram shows how decimal 41 = binary 101001:

Decimal		Binary					
10^1	10^0	2^5	2^4	2^3	2^2	2^1	2^0
↓	↓	↓	↓	↓	↓	↓	↓
10	1	32	16	8	4	2	1
4	1	1	0	1	0	0	1

Binary-Decimal Conversions

To convert from binary to decimal, the positional values for the 1's are added up. From the above example this would be:

$$2^5 + 2^3 + 2^0 = 32 + 8 + 1 = 41$$

To convert from decimal to binary, the decimal number is repeatedly divided by 2. The remainder is the binary equivalent. For example:

		Remainder (read up)
$2\overline{)41}$	→	1
$2\overline{)20}$	→	0
$2\overline{)10}$	→	0
$2\overline{)5}$	→	1
$2\overline{)2}$	→	0
$2\overline{)1}$	→	1

ASCII

Binary is often used as a code to represent not only numbers, but also alphanumeric characters such as "A" or "," or "?" or "x" or "2". One of the most-common binary codes used is ASCII[1]. ASCII is an eight-bit code, containing seven data bits and one parity bit. The General I/O Interface uses ASCII for most I/O operations. No parity bit is used. For example:

Character	ASCII Binary Code	ASCII Decimal Code
A	01000001	65
B	01000010	66
?	00111111	63

A complete list of ASCII characters and their equivalent binary and decimal representations is on pages 40-41.

[1]American Standard Code for Information Interchange.

Binary-Coded Decimal

Another often-used code for representing numeric values is Binary Coded Decimal (BCD). BCD is a four-bit binary code; each four bits represents a decimal digit from 0 through 9.

For example, to convert BCD 010000110110 to decimal:

BCD representation	0100	0011	0110
	↓	↓	↓
Decimal Value	4	3	6

The decimal equivalent number is found by breaking up the binary number into groups of 4 bits (starting from the right) and converting these groupings into decimal.

Octal-Binary Conversions

Octal is a base 8 number system. Octal numbers are often used since conversion from binary to octal and vice-versa is easy by using electronic circuits.

To convert from binary to octal, the octal number is broken up into groups of three bits (starting from the right). The groupings of 3 bits represent an octal number.

For example, to convert binary 10110100011001 to octal:

Binary Number	10	110	100	011	001
	↓	↓	↓	↓	↓
Octal Number	2	6	4	3	1

Notice that only values from 0 through 7 are used in octal.

To convert from octal to binary, the process is reversed:

Octal Number	1	4	0	7	2	6
	↓	↓	↓	↓	↓	↓
Binary Number	001	100	000	111	010	110

ASCII Character Codes

ASCII Char.	EQUIVALENT FORMS Binary	Octal	Dec [2]	CALCULATOR KEY [1]
NULL	00000000	000	0	—
SOH	00000001	001	1	—
STX	00000010	002	2	—
ETX	00000011	003	3	—
EOT	00000100	004	4	—
ENQ	00000101	005	5	—
ACK	00000110	006	6	—
BELL	00000111	007	7	—
BS	00001000	010	8	—
HTAB	00001001	011	9	↻
LF	00001010	012	10	. [3]
VTAB	00001011	013	11	—
FF	00001100	014	12	—
CR	00001101	015	13	ENTER ↑ [3]
SO	00001110	016	14	—
SI	00001111	017	15	—
DLE	00010000	020	16	—
DC1	00010001	021	17	—
DC2	00010010	022	18	—
DC3	00010011	023	19	—
DC4	00010100	024	20	—
NAK	00010101	025	21	—
SYNC	00010110	026	22	—
ETB	00010111	027	23	—
CAN	00011000	030	24	—
EM	00011001	031	25	—
SUB	00011010	032	26	—
ESC	00011011	033	27	—
FS	00011100	034	28	—
GS	00011101	035	29	—
RS	00011110	036	30	—
US	00011111	037	31	—

ASCII Char.	EQUIVALENT FORMS Binary	Octal	Dec [2]	CALCULATOR KEY [1]
space	00100000	040	32	RUN STOP [4]
!	00100001	041	33	SIN
"	00100010	042	34	+/-
#	00100011	043	35	LOG
$	00100100	044	36	LN
%	00100101	045	37	COS
&	00100110	046	38	[illegible]
'	00100111	047	39	+/-
(	00101000	050	40	P→R
)	00101001	051	41	ACC +
*	00101010	052	42	×
+	00101011	053	43	+
,	00101100	054	44	Σ+
-	00101101	055	45	−
.	00101110	056	46	.
/	00101111	057	47	÷
0	00110000	060	48	0
1	00110001	061	49	1
2	00110010	062	50	2
3	00110011	063	51	3
4	00110100	064	52	4
5	00110101	065	53	5
6	00110110	066	54	6
7	00110111	067	55	7
8	00111000	070	56	8
9	00111001	071	57	9
:	00111010	072	58	R↓
;	00111011	073	59	R↓
<	00111100	074	60	CL X
=	00111101	075	61	TAN
>	00111110	076	62	E EX
?	00111111	077	63	SIN

ASCII Char.	EQUIVALENT FORMS Binary	Octal	Dec [2]	CALCULATOR KEY [1]
@	01000000	100	64	I^{-1}
A	01000001	101	65	A
B	01000010	102	66	B
C	01000011	103	67	C
D	01000100	104	68	D
E	01000101	105	69	E
F	01000110	106	70	F
G	01000111	107	71	G
H	01001000	110	72	H
I	01001001	111	73	I
J	01001010	112	74	J
K	01001011	113	75	K
L	01001100	114	76	L
M	01001101	115	77	M
N	01001110	116	78	N
O	01001111	117	79	O
P	01010000	120	80	LOAD
Q	01010001	121	81	REWIND
R	01010010	122	82	RECORD
S	01010011	123	83	LIST
T	01010100	124	84	GO TO
U	01010101	125	85	LABEL
V	01010110	126	86	SFG · CFG ·
W	01010111	127	87	CLEAR
X	01011000	130	88	STORE
Y	01011001	131	89	RECALL
Z	01011010	132	90	END
[	01011011	133	91	P→R
\	01011100	134	92	LN
]	01011101	135	93	ACC +
^	01011110	136	94	R ↓
_	01011111	137	95	LOG

ASCII Char.	EQUIVALENT FORMS Binary	Octal	Dec [2]	CALCULATOR KEY
`	01100000	140	96	Σ+
a	01100001	141	97	A
b	01100010	142	98	B
c	01100011	143	99	C
d	01100100	144	100	D
e	01100101	145	101	E
f	01100110	146	102	F
g	01100111	147	103	G
h	01101000	150	104	H
i	01101001	151	105	I
j	01101010	152	106	J
k	01101011	153	107	K
l	01101100	154	108	L
m	01101101	155	109	M
n	01101110	156	110	N
o	01101111	157	111	O
p	01110000	160	112	LOAD
q	01110001	161	113	REWIND
r	01110010	162	114	RECORD
s	01110011	163	115	LIST
t	01110100	164	116	GO TO
u	01110101	165	117	LABEL
v	01110110	166	118	SFG · CFG ·
w	01110111	167	119	CLEAR
x	01111000	170	120	STORE
y	01111001	171	121	RECALL
z	01111010	172	122	END
{	01111011	173	123	CL x
|	01111100	174	124	COS
}	01111101	175	125	E EX
~	01111110	176	126	TAN
DEL	01111111	177	127	—

[1]The keys in color indicate the shifted keyboard state (see "The WRT∝ Instruction" in Section 2).
[2]Decimal numbers are used with READ BYTE and WRITE BYTE instructions.
[3]A CR and LF can be output by using ENTER ↑ in either keyboard state.
[4]The same character is output in either keyboard state.

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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 FIX, SCI, SCI 3, CALL LOOP / ALPHA, SFG / CFG, D (FOR), E (NEXT) or F (IF).
* 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 REWIND , 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.

HP 98134A General I/O Interface

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