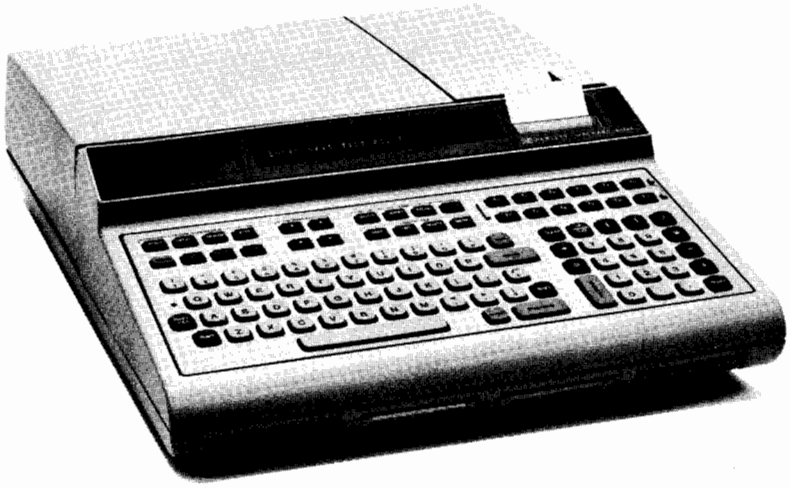
General I/O Programming



The HP 9825A Calculator

Hewlett-Packard Calculator Products Division
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(For World-wide Sales and Service Offices see back of manual.)

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General I/O ROM Operations

Operation	Description
Write	Output data or character strings to specified device.
Read	Request and input data or character strings.
Format	Specify data specs and edit specs for both read and write statements.
Conversion	Set up a character conversion table for read and write statements.
Write Binary	Output 16-bit binary numbers.
Read Binary	Input 16-bit binary numbers.
Write Control	Output binary status codes to an interface card.
Read Status	Check interface or peripheral status information.
List	Output program listings to an external device.

Manual Changes

HP 9825A Calculator
General I/O Programming

(For Manual P/N 09825-90024, Dated June 2, 1976)

Page 10:

Please add the following note to the bottom of page 10.

NOTE

If an unnumbered format statement is used, all subsequent input or output operations that do not reference a numbered format statement WILL reference the unnumbered format statement. To avoid undesired referencing of an unnumbered format statement, good programming practices dictate that all format statements should be numbered.

Page 27: The Write Binary Statement

Please add the following information to paragraph 1.

Usable range can be 0−65535 if flg 14 is set. Setting flg 14 overrides the overflow error normally encountered. (This is for any operation accepting 16 bit expressions.)

Page 33:

Please add the following information to the bottom of page 33.

Alternate Character Set

The 9825A calculator has an option which provides an alternate character set for the display and printer. The alternate character set is Katakana which is used in Japan.

If the Katakana option is installed, it can be selected by executing wtc 0,1. The normal character set is reselected by pressing RESET or executing wtc 0,0.

Without the optional alternate character set installed, `wtc 0,1` will disable the printer and the display. This should not be done when the calculator is in the print all mode, because the heating elements that produce the dots on the thermal paper may be left in the ON state, and they could be destroyed within seconds.

CAUTION

IF THE PRINTER IS ACTIVELY PRINTING, `wtc 0,1` SHOULD NOT BE EXECUTED BECAUSE IT COULD CAUSE THE PRINTER TO BURN OUT.

Executing `wait 500` before executing `wtc 0,1` will ensure that a print operation is complete before the printer and display are disabled; thus, avoiding the possibility of destroying the printer's heating elements.

Preface

An HP 9825A Calculator requires a General I/O ROM to control most peripheral devices. This manual describes the peripheral control statements and functions available with a General I/O ROM. The facing page lists the operations available with the ROM.

The instructions in this manual assume that you are already familiar with operating and programming the calculator. You should also be familiar with the unique operation and functions of each peripheral device to be controlled using the General I/O ROM.

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Chapter 4: HP Interface Bus

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Chapter 1
General Information

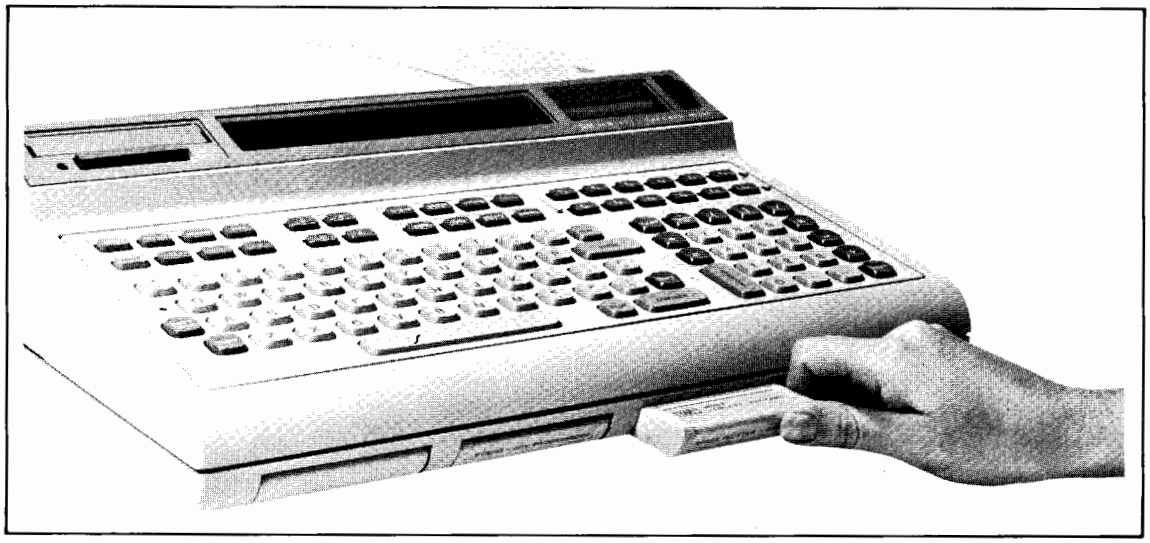
The General I/O ROM (Read Only Memory) provides a 9825A Calculator with the statements and functions for controlling most external peripheral devices. The ROM also permits formatting printouts on the internal printer and adds many additional characters for use with the printer and display. In addition to direct peripheral control, the General I/O ROM permits controlling individual peripherals via the HP Interface Bus.

Inspection Procedure

The General I/O ROM is packaged with other ROMs in a single ROM card. Please verify that the correct ROM card is supplied and inspect the card for physical damage. To check operation of the ROM, see the 9825A System Test Booklet. If any damage or electrical malfunction is found, contact the nearest HP Sales and Service Office; locations are listed near the back of this manual.

Installation

The ROM card can be plugged into any of the four slots on the front of the calculator (below the keyboard). To install the ROM, first switch off the calculator. Then, with the ROM label right-side-up, slide the card into the slot until it's even with the front of the calculator. Now, switch the calculator on.



Installing a ROM Card

Memory Usage

The General I/O ROM uses 56 bytes of calculator Read/Write Memory. This loss is indicated by the amount of available memory displayed after each list operation.

Syntax Guidelines

The following general conventions apply to the statement and function syntax listed in this manual.

- Dot matrix – All items appearing in `dot matrix` must be entered as shown.
- [ ] — All items in square brackets are optional and explained in the following text.
- All General I/O statements and functions can be executed either from the keyboard or a program.

A summary of General I/O syntax is listed at the back of this manual.

Error Messages

The General I/O ROM adds error messages G1 through G9 to the calculator error list. Meanings for each error are on the inside back cover.

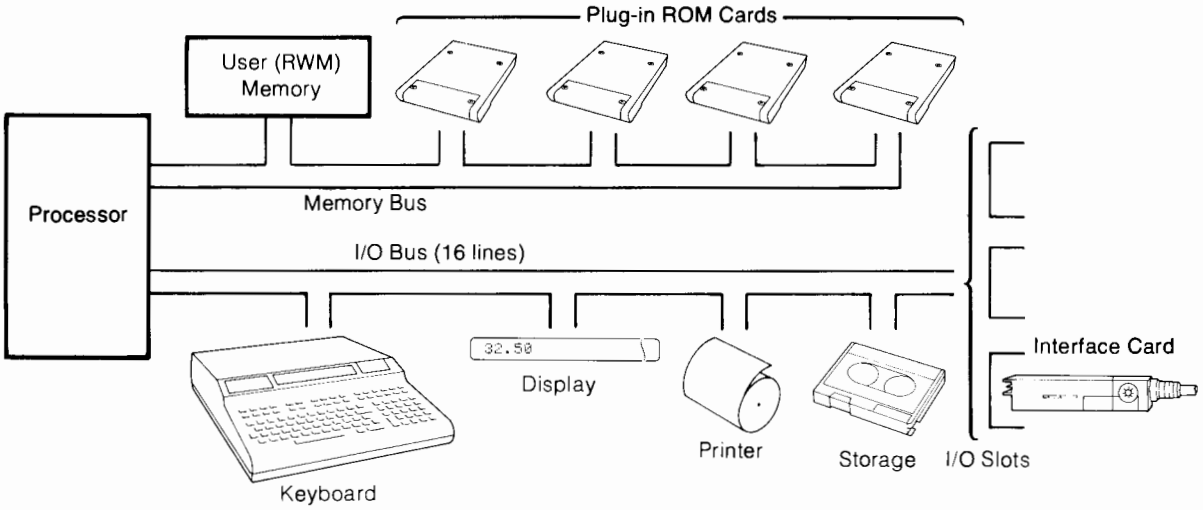
Chapter 2
Formatted I/O Operations

This chapter describes the General I/O statements which handle data in specialized formats. If you are using a General I/O ROM to control HP 9800-series peripherals, additional instructions are provided in an operating note furnished with each HP 98032A Interface Card.

Although interfacing a peripheral device to a calculator requires both hardware and software, this manual is concerned primarily with describing the input/output software available. To acquaint you with some interfacing terms, however, a brief discussion of the calculator input/output scheme is provided next.

Calculator I/O Scheme

The general calculator I/O scheme is shown in the next figure. Referring to the figure, notice that the I/O Bus transfers data between the calculator processor and peripheral devices. All incoming data is transferred through the processor before it is stored in memory. In this manual, the term "I/O" is always used with reference to the calculator.



The Calculator Input/Output Scheme

As shown in the figure, each external device must be connected to the calculator via an appropriate interface card and cable. The card plugs into any of the I/O slots in the calculator's back panel. As shown, plug-in ROM cards become a part of the calculator's memory; each card adds up to 8k bytes of ROM. Finally, notice that external devices share the I/O Bus with the internal peripheral devices (printer, display, etc.). So the internal peripherals respond to some General I/O operations, in addition to their specific commands (print, display, etc.).

Select Code

As just described, each external device is connected to the calculator via the same I/O bus. Since all external devices are "party-lined" on the same bus, each device is assigned a unique address, or select code, so that the correct device responds to each I/O operation.

For all external peripherals, the select code is an integer number from 2 through 15, which is specified in each I/O operation and decoded by the corresponding interface card. Each interface card has a switch permitting the user to set any one of many different codes. A list of recommended codes is in the Appendix.

Each internal peripheral has a fixed select code which is automatically specified by standard calculator statements (display, print, etc.). Both the display and the keyboard respond to select code 0, the tape drive responds to select code 1, and the printer responds to select code 16.

The select code can be specified in the form of a constant, a variable, or an expression. Each of these write statements is addressed to the device responding to select code 9 ◗

```
0: wrt 9,A,B,C
1: wrt S,A$ (S = 9)
2: wrt 3r1,A,B (r1 = 3)
```

For some operations, other numbers can be combined with the select code to form a single expression. A general select code syntax is:

cc[dd[ee]][.f]

cc= one or two-digit select code.
dd= optional HP-IB address code (must be two digits). See Chapter 4.
ee= optional HP-IB extended address code (use with Extended I/O ROM only). See The Extended I/O Programming Manual.
.f= format number (read and write statements only).

Input-Output Format

The I/O bus connecting the processor with internal and external peripherals contains 16 data lines. Data is transmitted in a 16-bit-parallel, character-serial fashion. The I/O operations described in this chapter send and receive data in standard 8-bit (US)ASCII code.[1] The calculator sends and receives one 8-bit character at a time. The parity (most-significant) bit is not used with formatted I/O operations. You'll find a brief introduction to binary coding and conversion in the Appendix. It's important to know the I/O formats available with each interface card; see the card's installation and service manual for details.

Peripheral Interrupt

Since the General I/O ROM is intended for use in systems where the calculator is the controlling device, there is no provision for peripheral interrupt operation (i.e., when an external device can call for an I/O operation). The calculator must be in complete control of each device while that device is involved in data transfer.

To enable the peripheral-interrupt capability available on some interface cards, such as the 98032A Interface, the Extended I/O ROM must be used. Refer to the Extended I/O Programming Manual for more information.

The Write Statement

wrt select code [, format no.][; expression or text$_1$[; expression or text$_2$...]]

The write statement outputs the characters, signs, and decimal point of each item to the specified peripheral. Each item in the list can be a numeric expression, text, or a string name (when the String ROM is in use). The value of each item is output in a free-field format unless a format statement is in effect. The format number can be an integer from 0 to 9 and references a similarly numbered format statement; format statements are described later.

Delimiters

A delimiter is a character that is used either to separate one expression from another inside the list or to terminate the list. The space (Δ) and the carriage-return line-feed (CR/LF) are delimiters that are automatically output during the execution of each write statement. The space is used to separate items within the list, and the CR/LF is used to terminate the list.

[1]American Standard Code for Information Interchange.

Free-Field Output Format

The free-field output format is automatically set whenever the calculator is switched on or [RESET] is pressed. Free-field is also set whenever run or erase all commands are executed. Each write statement references the free-field format until an appropriate format statement is executed; then the specifications in the format statement override free-field.

The free-field format causes each numeric expression to be output, right-justified, in an 18-character field. A CR/LF is given after every fourth expression output and after the last parameter is output. The form in which expressions appear is determined by the current fixed (fxd) setting. Characters within quotes and strings are output as "free text", which means that the 18-character fields are not used.

Here are some examples using free-field. The output device used here is an HP 9866B Printer, connected via a 98032A Interface set to select code 6. For more examples, see "Format Statements" in this chapter; also see Chapter 4.

First, press [RESET]

Then load and run this program ▶
The output is shown below.

```
0: fxd 4;10→A
1: wrt 6,A,A/9,
 A/A1≤4
2: end
```

```
        10.0000          1.1111          0.0001 CR/LF
```

18-char. field | 18-char. field | 18-char. field

Now change line 1 and run the program again.

```
0: fxd 4;10→A
1: wrt 6,A,A↑2,
 A↑4,A↑6,A↑8
2: end
```

```
        10.0000        100.0000      10000.0000    1000000.0000
100000000.0000 CR/LF                                      CR/LF
```

Notice that a CR/LF is automatically output after the last item and after each four items.

To output text between numeric expressions, change line 1 again and run the program ▶

```
0: fxd 4;10→A
1: wrt 6,A,"mete
 rs",A1e2,"cm",
 A1e4;"mm"
2: end
```

```
 10.0000meters      1000.0000cm      100000.0000mm CR/LF
└──────────┘      └──────────┘      └──────────┘
   w = 18            w = 18            w = 18
```

As shown in the printout, text is output between numeric fields with free-field. For complete control of numeric and text outputs, use format statements.

The Read Statement

red select code[, format no.], variable$_1$ [, variable$_2$...]

The read statement inputs and stores data from a specified peripheral[1]. The number of variables in the list indicates how many data items to read. String variable names (but not substrings) can be used if the String ROM is in use. Each numeric data item can consist of the digits 0 through 9, plus and minus signs, a decimal point, and an "E" character (upper and lower case). All other characters are treated as input delimiters. The data item itself can assume the same form as any number entered from the keyboard.

The format number can be used to reference any of ten format statements. If a format number is not specified, and if a format statement has not been previously executed, a free-field input format is automatically used.

[1]The calculator keyboard can not be used to input data with a read statement. Use an enter statement instead.

Free-Field Input Format

The free-field input format is set whenever the calculator is switched on or [RESET] is pressed. Free-field is also set whenever run or erase all commands are executed. Using free-field allows reading numeric data in virtually any form, provided that each item is followed by at least one delimiter (non-numeric character). For each variable in the read list, the calculator ignores all leading non-numeric characters until a numeric characters is read. Then, after reading the data item, reading any non-numeric character terminates and stores the data item. Also, reading a LF terminates the entire read operation.

When free-field is used, the calculator cannot input non-numeric characters unless a string variable (String ROM) is specified. Then all characters are input until the dimensioned string length is filled. Reading a LF (during free-field) automatically terminates reading a string. Also see "Format Statements" later in this chapter, and the String Variables Programming Manual.

Here is a brief description of the delimiters used in the free-field input format:

- If the first character is a comma, the corresponding variable in the read statement is skipped and flag 13 is set. The skipped variable keeps its original value.
- All non-numeric characters preceding a data item are ignored. If a continuous string of the same non-numeric character is received, each variable in the read list is skipped and flag 13 is set after 2^{16} characters are read.
- An HT (horizontal tab) character causes the calculator to skip all characters until a LF is read.
- Whenever a LF is read (and it does not correspond to a preceding HT) the read statement is terminated and flag 13 is set.
- An upper- or lower-case "E" character, when part of any of these forms, causes the preceding data item to be multiplied by the power of 10 indicated:

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

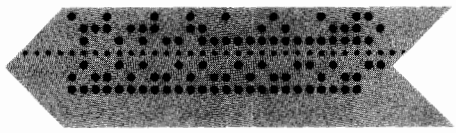
For example, any of these data items will be read as the number "1234" (Δ indicates space):

1.234E3
1.234EΔ3
1.234E+3
1234000E−3

- Spaces read within numeric characters are ignored.
- The CR (carriage return) is always ignored (skipped over) during a read operation.

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

1.23,2.34,3.45,4.56,,5.67 (CR)(LF)



The program assumes that the tape reader interface is set to select code 3. Run the program twice to obtain both printouts.

Notice that the read operation is terminated when the required number of items have been read, or when a LF is read. In the second printout, r2 was skipped and so retained its original value (the run command clears all variables).

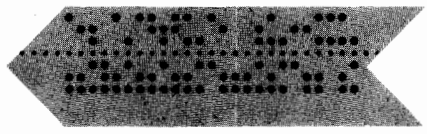
```
0: 0→r1→r2→r3
1: red 3,r1,r2,
 r3
2: fxd 2
3: prt r1,r2,r3
4: spc 2;end
```

```
1.23
2.34
3.45

4.56
0.00
5.67
```

As another example, use the previous program to read this tape ⏵

12.81,13.35,(HT)200.5,(LF)25E5



The calculator ignores all data between HT and LF characters. More examples using read statements are in the next section and in Chapter 4.

```
12.80
13.35
2500000.00
```

Format Statements

Use of format statements provides more flexible and complete control of write and read statements. A format statement must be executed before the I/O statement referencing it and provides a list of specifications for use by the I/O statement. Then, as the I/O statement is executed, it references the last-executed format statement rather than free-field.

The Format Syntax

fmt[format no.][spec$_1$[,spec$_2$...]]

The format number can be used to identify the statement for successive write or read statements. Each format number can be an integer constant from 0 to 9; if not specified, 0 is assumed. When the calculator is reset (power on, RESET, run, or erase all) format number 0 is automatically assigned to specify free-field. Also, the syntax fmt[format no.] assigns the format number to free-field.

For example, if the numbered format statements shown here appear in a program, then the write statements in lines 6 and 9 reference format no. 2, and the read statement in line 7 references format no. 9. The last two I/O statements reference free-field, however, since they do not specify a format no. and there is neither a format 0 nor an unnumbered format statement.

```
0: fmt 2,f10.2
1: fmt 5,e15.0
2: fmt 9,f6
        ●
        ●
        ●
6: wrt 6.2,A,B
7: red 3.9,r1
8: for I=1 to 9
9: wrt 16.2,rI
10: next I
11: wrt 16,A,B
12: red 7,A$
```

Each successive format statement replaces any previous, similarly-numbered format statement. A format statement with no parameters sets free-field. In the example sequence on the right, the first unnumbered format statement specifies free-field for the read statement. The write statements in lines 16 and 18 reference the second unnumbered format (line 14). The last two write statements reference the third unnumbered format (line 19).

```
13: fmt ;red 3,
 A,B,C,D,E
14: fmt c50
15: fmt 1,5f10.0
16: wrt 6,A$
17: wrt 6.1,A,B,
 C,D,E
18: wrt 6,B$
19: fmt "end",5/
20: wrt 6
21: wrt 16;end
```

Data Output Specifications

Data specs determine the form in which each data item is output. Most data specs determine whether a number is output in fixed point or floating point, the number of digits to the right of the decimal point, and the character field width in which the number appears.

These data specs are available:

[r]fw.d	Specifies fixed-point format.
[r]ew.d	Specifies exponential (floating-point) format.
[r]fzw.d	Specifies fixed-point format with leading zeros in each field. Negative numbers are not allowed with this format.
[r]b	Specifies binary output of single characters. Examples begin on page 14.
[r]cw	Specifies a character field-width for either text or a string variable (String ROM).

- r is an optional repeat factor (see examples). If r is omitted, 1 is assumed.
- w indicates total field width (in characters). If w is omitted,leading spaces are deleted from the field.
- d indicates the number of digits (0 through 11) to the right of the decimal point. If d is omitted or if d is greater then 11, the current fixed or float setting is used.
- w, d and r parameters must be positive integer constants.

For example, the data spec f8.2 specifies a fixed-point number with two digits to the right of the decimal point. The number appears (right-justified) in an eight-character field. If d is 0, the decimal point is not output. A number output under a data spec is always rounded according to the number of decimal places specified. The free-field format is equivalent to 4f18.

Some guidelines should be observed in selecting w and d. The minus sign, decimal point, and exponent are part of each number and must fit in the field width specified by w. For floating-point outputs, w should be greater than or equal to d+7. If the calculator cannot output the data in the field width available, the field is filled with $s.

The following examples of formatted output use the calculator's internal printer as the output device (select code 16).

Lines 1 and 2 output three numbers. Since the entire format statement is referenced for each number, a CR/LF is output after each.

```
0: 10→A;.5→B;
 16→C
1: fmt f10.2
2: wrt C;A,B,
 AB↑2
```

```
     10.00
      0.50
      2.50
```

w = 10

Lines 3 and 4 output the same numbers as above, but use of a repeat factor matches the data spec to the output list – so all numbers appear on the same line.

```
3: fmt 3f5.2
4: wrt C;A,B,
 AB↑2
```

```
10.00 0.50 2.50
```

w = 5 w = 5 w = 5

This sequence outputs numbers in various formats. Line 10 increments the format number, so that all formats are referenced. Outputs are shown below.

```
5: fmt f8.1,e8.1
6: fmt 1,4f4.0
7: fmt 2,4f.0
8: fmt 3,fz16.2
9: wrt C;A,2A↑2,
 3A↑3,4A↑4
10: if (C+.1→C)<
 16.4;jmp -1
11: end
```

Format 0: Format 0 is referenced twice in line 9. Note than an upper-case E precedes the exponent.

```
   10.0 2.0E 02
 3000.0 4.0E 04
```

Format 1: Notice that $s fill the last field since the number is too large for the field width specified.

```
 10 2003000$$$$
```

Format 2: Notice that omitting w deletes leading spaces from each field.

```
102003000040000
```

Format 3: The last format outputs the same numbers in a single column with leading zeros in each field.

```
000000000010.00
000000000200.00
000000003000.00
000000040000.00
```

Text Character Fields

The c data spec specifies a fixed character field for corresponding text or a string variable in the write statement. The characters are output right-justified in the field. If the field is too small, it's filled with $s.

In the example on the right, the first two lines of text fill the field; the third line is too short; the last line is too long.

```
0: fmt c10,f5.1
1: wrt 16,"Funct
 ion =",A
2: wrt 16,"Polar
 ity =",C
3: wrt 16,"Phase
  =",B
4: wrt 16,"Avera
 ge Value =",D+
 E→E
```

```
Function =   0.0
Polarity =   0.0
   Phase =   0.0
$$$$$$$$$$   0.0
```

w = 10

Output Edit Specifications

These edit specs are used to control the placement of output data and to output character strings:

[r] x	Outputs a blank character space.
[r] /	Outputs a CR/LF.
[r] "TEXT"	Outputs the ASCII characters within quotes. See the following examples and the Appendix.
z	Suppresses the automatic CR/LF output after each write statement.

Any combination of specs can appear in the same format statement; each spec must be separated by a comma. Most of the specs can be duplicated r number of times by using the repeat factor.

For example, referencing this statement causes the first fixed-point field to appear twice, followed by four character spaces, and then another fixed-point field.

```
0: fmt 2f6.2,4x,
 f10.1
```

The program on the right shows how to format a three-column table using the internal printer. You can use the same method, of course, with external output printers.

```
0: 1→A
1: ent r1,r2,r3,
 r4,r5
2: fmt 2/
3: fmt 1,2x,"n",
 3x,"n",b,3x,"1/
 n"
4: fmt 2,16"-"
5: fmt 3,f3.0,
 f6.0,f6.3
6: wrt 16;wrt
 16.1,29;wrt
 16.2
7: wrt 16.3,rA,
 rA↑2,1/rA;jmp
 (A+1→A)=6
8: wrt 16;end
```

Suppose that the entered values are 5, 9, 15, 25, and 64. When formats 0, 1 and 2 are referenced in line 6, CR/LFs and the column headers are output. Notice that spaces are used to position the characters, and that a b data spec causes the binary value of decimal 29 to be output, printing the character ². (The complete character set is shown later.) Then line 7 references format 3 for the numeric outputs. Here, spacing is determined by the data field widths.

```
  n    n²    1/n
----------------
  5    25 0.200
  9    81 0.111
 15   225 0.067
 25   625 0.040
 64  4096 0.016
```

The next program, which produces a table of trigonometric values, uses a 9866B Printer. Although the program is similar in programming technique to the previous one, here are some exceptions (a sample printout is on the next page):

- Spacing between table columns is achieved by placing blocks of spaces between each number, rather than by adjusting the width of each data field.
- Notice the use of text (in line 5) to enclose the radians entries.

```
0: fmt 1,5/;wrt
 6,1
1: fmt 30x,"Trig
 onometric Table
 ",2/;wrt 6
2: deg;sfg 14;
 0→A→X
3: fmt 2,6x,"Deg
 rees (Radians)"
 ,12x,"Sine",
 10x,"Cosine",
 12x,"Tangent",/
4: wrt 6,2
5: fmt 3,9x,f3.0
 ," (",f4.2,")",
 15x,f6.3,9x,
 f6.3,10x,e10.3
6: wrt 6.3,X,πX/
 180,sin(X),cos(
 X),tan(X)
7: A+1→A
8: if A=3;0→A;
 fmt ;wrt 6
9: if 180>X;X+
 10→X;gto 6
10: wrt 6,1
11: end
```

Trigonometric Table

Degrees (Radians)	Sine	Cosine	Tangent
0 (0.00)	0.000	1.000	0.000E 00
10 (0.17)	0.174	0.985	1.763E-01
20 (0.35)	0.342	0.940	3.640E-01
30 (0.52)	0.500	0.866	5.774E-01
40 (0.70)	0.643	0.766	8.391E-01
50 (0.87)	0.766	0.643	1.192E 00
60 (1.05)	0.866	0.500	1.732E 00
70 (1.22)	0.940	0.342	2.747E 00
80 (1.40)	0.985	0.174	5.671E 00
90 (1.57)	1.000	0.000	9.999E 99
100 (1.75)	0.985	-0.174	-5.671E 00
110 (1.92)	0.940	-0.342	-2.747E 00
120 (2.09)	0.866	-0.500	-1.732E 00
130 (2.27)	0.766	-0.643	-1.192E 00
140 (2.44)	0.643	-0.766	-8.391E-01
150 (2.62)	0.500	-0.866	-5.774E-01
160 (2.79)	0.342	-0.940	-3.640E-01
170 (2.97)	0.174	-0.985	-1.763E-01
180 (3.14)	0.000	-1.000	0.000E 00

Printer Character Set

The program on page 14 shows how to print a new character on the internal printer. As shown in the next program, the b data spec can be used to print any character in the printer's character set.

The program on the right prints numbers 0 through 127. It also outputs each number's binary-equivalent value, causing the printer to output its entire character set. A complete printout is shown.

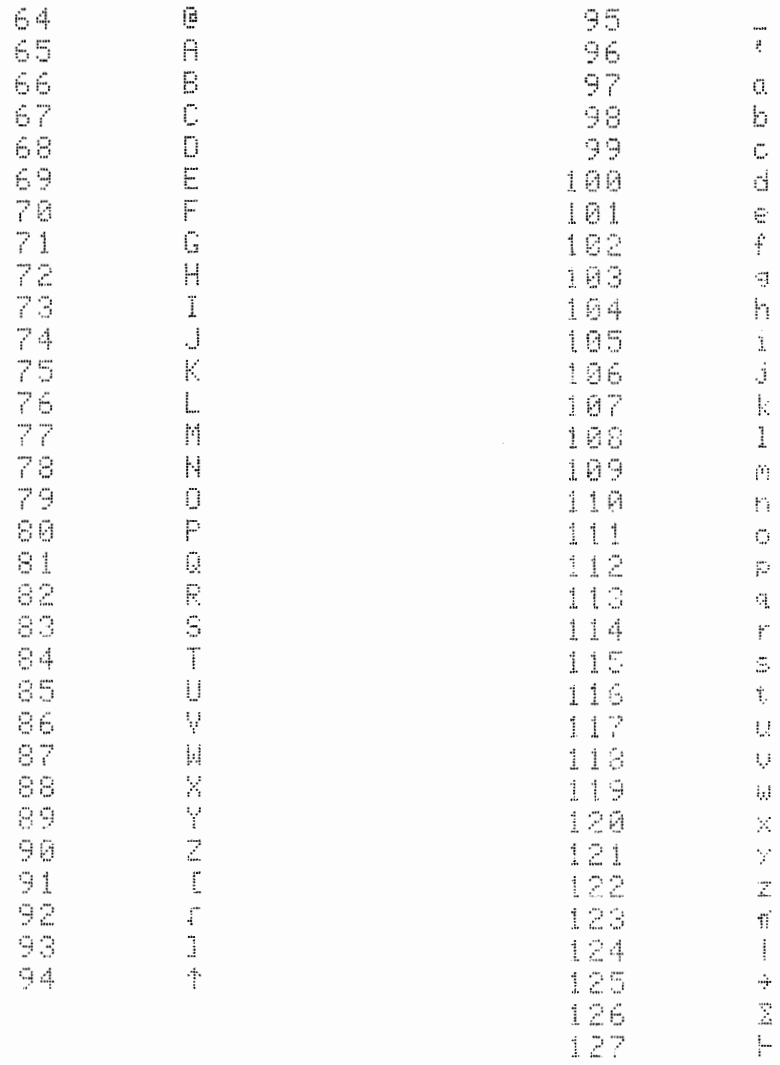
```
0: wrt 16,"CHARA
 CTER SET"
1: fmt f3.0,6x,b
2: wrt 16,I,I
3: if (I+1→I)<12
 8;jmp -1
4: spc 2;end
```

Internal Printer Character Set

```
CHARACTER SET
  0        ¶
  1        ☺
  2        ☒
  3        ♣
  4        α
  5        θ
  6        Γ
  7        π
  8        Δ
  9        σ
 10        (line feed)

 11        ^
 12        μ
 13        (carriage return)
 14        ↑
 15        ↓
 16        Θ
 17        Ω
 18        δ
 19        ∞
 20        ∂
 21        Ä
 22        ä
 23        Ö
 24        ö
 25        Ü
 26        ü
 27        É
 28        é
 29        ≥
 30        £

 31        ▒
 32        (space)
 33        !
 34        "
 35        #
 36        $
 37        %
 38        &
 39        '
 40        (
 41        )
 42        *
 43        +
 44        ,
 45        -
 46        .
 47        /
 48        0
 49        1
 50        2
 51        3
 52        4
 53        5
 54        6
 55        7
 56        8
 57        9
 58        :
 59        ;
 60        <
 61        =
 62        >
 63        ?
```



Referring to the printout, notice that most of the characters and decimal numbers correspond to ASCII codes (see the table in the Appendix). But notice that two codes, 10 and 13, do not generate printer characters. Instead, 10 causes the printer to linefeed and 13 is ignored.

Another method of listing the printer character set is to print a string variable (String ROM) containing character values from 0 through 127. Here's the program and printout.

```
0: dim A$[128]
1: 0→I
2: char(I)→A$[I+
 1]
3: if (I+1→I)<12
 8;jmp -1
4: prt A$
5: end
```

```
                    10  13
                    ↓   ↓
¶¿ÆÑαßΓπΔσ↓∧μ÷τ$
ΘΩδÁáÄäÖöÜÜÆæ²£▒
 !"#$%&'()*+,-./
0123456789:;<=>?
@ABCDEFGHIJKLMNO
PQRSTUVWXYZ[Γ]↑_
'abcdefghijklmno
pqrstuvwxyzπ|→Σ⊢
```

Notice that with a print statement, the printer generates characters for string values 10 and 13. But if the string is output to the printer using a write statement (see the next line and printout), the printer does a line feed for 10 and ignores 13.

```
4: wrt 16,A$
```

```
¶¿ÆÑαßΓπΔσ
∧μτ$ΘΩδÁáÄäÖöÜÜÆ
 ↑ ↑
12 14
```

This last printout shows another important point: The internal printer does line feeds during a print statement to accommodate long strings or text, but it does not automatically do line feeds for write or write binary statements. The second line in this last printout was printed because of the line feed automatically output after the write statement.

Similarly, line feeds must be sent to the display when using write or write binary statements. If not, output data will be lost. For example, execute this line:

```
wrt 0,"Keeper"
```

```
Keeper
```

Now add `fmt z;` and execute the line again:

```
fmt z;wrt 0,"Keeper"
```

```
⊢
```

Display Character Set

The same character set available on the internal printer is available for use in the display by using the b data spec. Also, adding 128 to each item output with b causes a character-editing cursor (◀ or ▮) to flash over each corresponding character. The cursor which appeared last in the display is used for this operation.

For example, this sequence ▶ displays the message "Program Secured!" in a field filled with flashing cursors. The resulting display is shown below.

```
5: 32+128→C
6: fmt 8b,"Progr
 am Secured",9b
7: wrt 0,C,C,C,
 C,C,C,C,C,33,C,
 C,C,C,C,C,C,C
8: end
```

Single Character Output

To output single ASCII characters without CR/LFs, use either the write binary statement described in Chapter 3, or one of these methods:

fmt "characters",z;wrt select code

or

fmt b,z;wrt select code, decimal value

For example, the plug-in unit in an HP 3480 Digital Voltmeter can be remotely controlled by using appropriate ASCII characters. The plug-in unit is connected via an HP 98032A I/O Interface Card (select code 2). The DVM mainframe is connected via an HP 98033A BCD Interface (select code 3).

In this program sequence, first the 3484A Plug-in Unit is set to the 100 mV range by sending an ASCII "EOM" (decimal 4); then a data reading is taken. Line 8 sets the plug-in unit to the 1 V range by sending an ASCII "@" (decimal 64) before another reading is taken.

```
5: fmt 1,b,z
6: wrt 2.1,4
7: red 3,A,B
8: wrt 2.1,64
9: red 3,A,C
```

Text in Format and Write Statements

As shown in the preceding examples, text to be output can be included in format or write statements. For programming convenience, however, it's recommended that text **not be placed**: 1) in both format and write statements for a given output, and 2) as the last item in a write statement. The following examples show why.

Suppose that we wish to output this line on an external printer ("DM" indicates Deutsche Marks):

```
Sales =    10DM for the last   4 months.
          w = 6               w = 3
```

This sequence could be used with no problem (assume that A = 10 and B = 4):

```
0: fmt "Sales =",f6.0,"DM for the last ",f3.0," months."
1: wrt 6,A,B
```

Notice that all text is in the format statement. If all text were placed in the write statement:

```
0: fmt f6.0,f3.0
1: wrt 6,"Sales =",A,"DM for the last ",B," months."
```

This output would result:

```
Sales =    10DM for the last   4
 months.
```

Since there were more output items than format specs, a CR/LF was output after the last spec was referenced. Then "months" was output, followed by another CR/LF, at the end of the write statement.

Now suppose that we wish to output the same line, but have each write statement determine the units: "DM...months" on one line and "K$...days" on another line. Here is one method and its results:

```
0: fmt "Sales =",f6.0," for the last ",f3.0,c
1: wrt 6,A,"DM",B," months."
2: wrt 6,A,"k$",B," days."
```

```
Sales =    10 for the last DM  4 months.
Sales =    10 for the last k$  4 days.
```

The problem of extra CR/LFs is avoided here by referencing data spec c. But notice that text preceding each spec is output **before** text preceding each variable. So the units DM and K$ are in the wrong place! To output the units in the correct order, use more c specs:

```
0: fmt "Sales =",f6.0,c," for the last ",f3.0,c
1: wrt 6,A,"DM",B," months."
2: wrt 6,A,"k$",B," days."

     Sales =    10DM for the last   4 months.
     Sales =    10k$ for the last   4 days.
```

When using text in format and write statements, remember:

- Place all "fixed" text in the format statement.
- Place all "variable" text in the write statement and reference c data specs.
- Text (and all other edit specs) preceding each data spec are always output **before** text preceding the corresponding item in the write statement.

Data Input Specifications

Data specs can be used to determine which characters are input from a data input string, and in what form the data will appear. When a format statement is referenced by a read statement, the read operation is not terminated until a LF character is read (unless the edit spec z is used). A general data input spec syntax is:

[r]f[w]

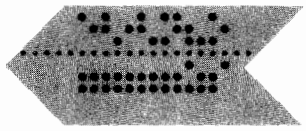
- r is the number of consecutive times the spec is to be used (if r is 1 it may be omitted). r and w must be integer constants.
- w is the width of the data field to be read. Omitting w specifies free-field read for the corresponding item(s).

A data spec like f10 calls for reading ten numeric characters; all non-numerics which precede a numeric are counted but not entered. If an "E" is read within a numeric field, a number of the form 1e dd is entered.

The following examples use an HP 9883A Tape Reader via a 98032A Interface set to select code 3. The paper tapes shown here are coded in ASCII.

To read this tape containing three data items ▸ run this program.

123423453.45 (LF)



```
0: fmt 3f4
1: red 3,A,B,C
2: fxd 2
3: prt A,B,C
4: end
```

```
1234.00
2345.00
   3.45
```

Notice that four characters were read for each data item.

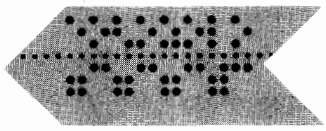
Now delete line 0, and run the program to read the same tape again.

```
123423453.45
        0.00
        0.00
```

Referencing free-field inputs the entire data string into the first variable; reading the LF terminates the read operation, skipping the last two variables.

To read this tape ▸ run this program.

12 (CR)(LF) 34 (CR)(LF) 56 (CR)(LF) 78 (CR)(LF)



```
0: 1→A;fmt f3
1: red 3,rA;jmp
  (A+1→A)>4
2: fxd 0
3: prt r1,r2,r3,
  r4
4: end
```

```
12
34
56
78
```

Since there is a LF character after each data item, the read statement had to be repeated to input each item.

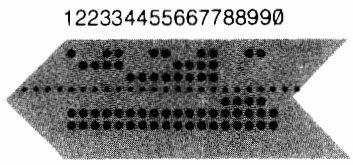
Input Edit Specifications

The following edit specs can be used to increase input format flexibility. An example use of each spec follows.

z	Cancel LF as terminator.
[r] x	Skip character.
[r] /	Skip data item.
[r] c w	String field width.

The z spec causes the calculator to read only the number of characters specified in the rest of the format statement. The read operation is automatically terminated after the characters are read, without the need for a LF character.

For example, this tape has 9 two-digit numbers, but no LF character ◆



Run this program to read and print all nine items.

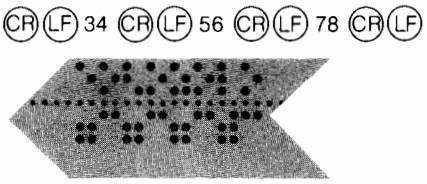
```
0: 1→A                          12
1: fmt z,f2                     23
2: red 3,rA;jmp                 34
 (A+1→A)>9                      45
3: 1→A;fxd 0                    56
4: prt rA;jmp                   67
 (A+1→A)>9                      78
5: end                          89
                                90
```

The x spec causes the calculator to skip (not count) r number of characters. For example, to read and skip alternate items on the previous tape, run this program. Notice that the entire format statement is referenced for each data entry.

```
0: fmt z,f2,2x                  12
1: red 3,A,B,C,                 34
 D,E                            56
2: fxd 0                        78
3: prt A,B,C,D,                 90
 E
4: end
```

The / spec causes the calculator to skip all data which precedes r number of CR/LF characters.

For example, to read only the first and last items on this tape ▸
run the program shown below.




```
0: fmt f2,3/,f2
1: red 3,A,B
2: fxd 0
3: prt A,B
4: end
```

```
12
78
```

The c spec indicates the number of characters to input into a dimensioned string variable (String ROM). All characters are entered until either the dimensioned string is filled, or w characters are read. When c is used, reading a LF does not terminate a string input.

Reading into a string variable is a convenient way of storing all characters in a data item, including non-numerics. Later, any character or portion of the string can be evaluated using String ROM operations.

For example, the HP 98033A BCD Interface inputs data from a measurement device, such as an HP 3480 Digital Voltmeter, and transfers ASCII-coded data to the calculator in this 16-character format:

(sign) D_1 D_2 D_3 D_4 D_5 D_6 D_7 D_8 E (sign) D_9, (overload) D_{10} LF

Since a delimiter follows each data item, it's easy to read the numeric items by using a read statement with free-field format.

```
0: red 3,r1,r2
```

By reading into a string variable, however, you can evaluate any portion (substring) of the string later in the program. Running this sequence stores the data reading in A, the overload numeric character in B, and the function code in C.

```
1: dim A$[20]
2: fmt c16
3: red 3,A$
4: val(A$[1,12])
  →A
5: val(A$[14,
  14])→B
6: val(A$[15,
  15])→C
```

See the String Variables Programming Manual for other String ROM operations.

The Conversion Statement

conv [code$_1$, code$_2$[, code$_3$, code$_4$]...]

The conversion statement sets up a character replacement table for use with read and write statements. Up to 10 pairs of decimal codes can be specified at a time. Each new conversion statement cancels the previous table and sets up a new one. A conversion statement with no parameters cancels any previous table.

In this program sequence
line 8 sets up a conversion table which changes the spaces (decimal 32) output between numbers in line 10 to asterisks. Then line 11 cancels the previous table.

```
8: conv 32,42
9: fmt 3f10.2
10: wrt 6,A,B,C
11: conv
```

As another example, line 6 on the right specifies that whenever an ASCII "/" (decimal 47) is read in line 7, it will be converted to an ASCII "HT". Also, whenever an ASCII "NULL" is read, it will be converted to an ASCII "CR" (decimal 13). Changing these input delimiters causes the calculator to skip all characters read between a / and a LF, and ignore all NULL characters. Input delimiters are described on page 8.

```
6: conv 47,9,0,
 13
7: red 3,A$
```

The List Statement

A select code parameter can be used with the list statement when the General I/O ROM is plugged in, enabling program listing on a peripheral output device. The new list syntax is:

list [#select code][, line nos.]

The optional line numbers remain as described in the operating and programming manual.

A listing of the same program described on page 15 is shown next, output to a 9866B Printer via a 98032A Interface set to select code 6. Referring to the listing, notice that three CR/LFs are automatically output before and after the listing.

```
0: fmt 1,5/;wrt 6.1
1: fmt 30x,"Trigonometric Table",2/;wrt 6
2: deg;sfg 14;0→A→X
3: fmt 2,6x,"Degrees (Radians)",12x,"Sine",10x,"Cosine",12x,"Tangent",/
4: wrt 6.2
5: fmt 3,9x,f3.0," (",f4.2,")",15x,f6.3,9x,f6.3,10x,e10.3
6: wrt 6.3,X,πX/180,sin(X),cos(X),tan(X)
7: A+1→A
8: if A=3;0→A;fmt ;wrt 6
9: if 180>X;X+10→X;gto 6
10: wrt 6.1
11: end
*24841 ←checksum
```

If not needed, the CR/LFs and checksum can be suppressed by adding a decimal point and a non-zero digit to the select code. For example, use this statement to list the last half of the program shown above: `list#6.1,5`

```
5: fmt 3,9x,f3.0," (",f4.2,")",15x,f6.3,9x,f6.3,10x,e10.3
6: wrt 6.3,X,πX/180,sin(X),cos(X),tan(X)
7: A+1→A
8: if A=3;0→A;fmt ;wrt 6
9: if 180>X;X+10→X;gto 6
10: wrt 6.1
11: end
```

The checksum and CR/LFs are not suppressed when this list statement is used with the internal printer (select code 16).

Chapter 3
Binary I/O Operations

Binary I/O operations are available to read and write individual data characters, and to transmit or receive control information using interface status lines. Binary I/O operations do not reference format or conversion statements. The data I/O modes and status line meanings are determined by the interface card; refer to each card's installation and service manual for details.

The Write Binary Statement

wtb select code [,] expression or text$_1$ [[,] expression or text$_2$...]

This statement outputs the 16-bit, binary-equivalent result of each expression or each character of text. The usable range for each expression is an integer from −32768 through 32767. If the interface handles data in an 8-bit fashion, as does the HP-IB Interface or the 98032A Interface with byte mode, only the 8 least-significant bits of each integer are accepted by the interface.

Here is a short program which uses write binary to print the same title and internal-printer character set as shown on pages 16-17. A portion of the printout is also shown below. Notice that a line feed (decimal 10) must be sent at the end of each statement to print the line (line feeds are not automatically sent after binary output operations).

```
0: 0→A
1: wtb 16,"CHARA
 CTER SET",10
2: wtb 16,A,10
3: if (A+1→A)<12
 8;jmp -1
4: end
```

```
CHARACTER SET
◀
¿
x̄
N̄
α
ß
Γ
π̄
Δ
σ
```

The HP 9871A Printer has a variety of functions that are controlled by using sequences of decimal codes. Here are program segments that set the top of form (decimal codes 27 and 84) in line 6 and form length (27,70, int (n/64),int n) in line 7. For a form length of 8 inches, n is 768. Line 15 outputs a form feed instruction. The printer interface is set to select code 6.

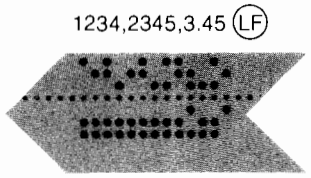
```
6: wtb 6,27,84
7: wtb 6,27,70,
 int(768/64),768
     ●
     ●
     ●
15: wtb 6,12
```

The Read Binary Function

rdb (select code)

Read binary is a function that inputs one 16-bit character and stores its integer-decimal value. If the interface handles data in an 8-bit fashion, the eight most-significant bits are read as zeros.

For example, to read this ASCII-coded paper tape ➧



Run the next program ➧
The program assumes that the HP 9883A Tape Reader's interface responds to select code 3.

```
0: fxd 0
1: prt rdb(3)→A
2: if A#10;jmp -
 1
3: end
```

Notice that the read binary function is programmed as part of the print statement. Line 2 continues the program until a LF is seen. Compare the list of decimal numbers with the ASCII characters listed in the Appendix.

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

As an interesting exercise, execute this line ▸

```
wrt 16,rdb(0);jmp 0
```

Now press each key, except [RESET], to print its decimal equivalent code. Notice that Live Keyboard is disabled while it is involved in an I/O operation. To halt the calculator, press [RESET].

The decimal key codes returned by using this method generally do not correspond to ASCII decimal codes. A complete set of decimal key codes is in the Appendix.

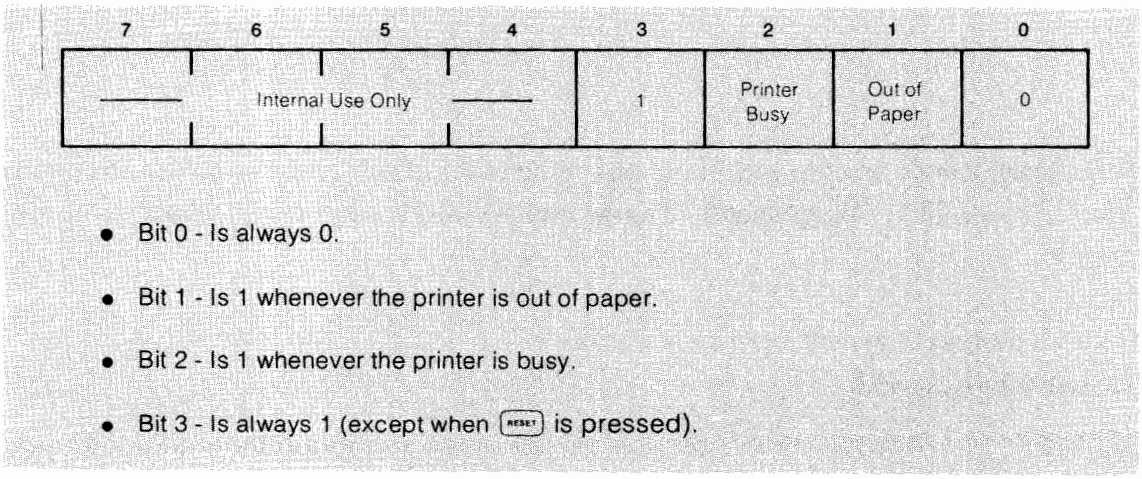
The Read Status Function

```
rds (select code)
```

This function reads the current status information transmitted from the specified device and returns a decimal-equivalent number. The number of status bits and their meanings are described in each interface installation and service manual. The status information available from the HP 98032A Interface Card is described later in this section.

KDP Status Bits

Status information from the calculator's keyboard (K), display (D), and printer (P) is combined into an 8-bit byte. Although most of the bits are for internal use only, two bits have programming uses:



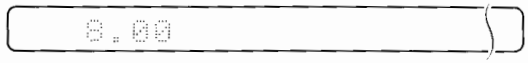
- Bit 0 - Is always 0.
- Bit 1 - Is 1 whenever the printer is out of paper.
- Bit 2 - Is 1 whenever the printer is busy.
- Bit 3 - Is always 1 (except when [RESET] is pressed).

KDP Status Bits

So, if paper is loaded in the calculator, store and run this line (use either select code 0 or 16) ◗

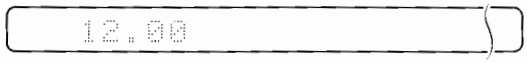
```
0: dsp rds(16);
 wait 100;jmp 0
```

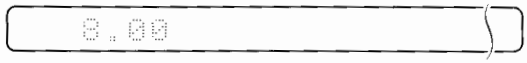
The display should flash continually ◗



Bit 3 will always appear as "1" (binary 8) to the read status function.

Now press [PRT ALL]. Now the display is ◗ since the printer is busy in the print all mode. Press [PRT ALL] again to switch the mode off. Notice that status bit 2 (decimal 4) is added to the byte whenever the printer is busy.





The segment on the right shows how to avoid error 15, out of paper, by watching for the addition of status bit 1 (decimal 2). When a status byte of 10 is returned, the rest of line 0 is executed.

```
1: if rds(16)=10
 ;dsp "out of
 paper→→→";stp
2: prt A$
```

The above method works, provided that the printer is not busy. The lines on the right check for both status bytes which indicate "out of paper".

```
3: if rds(16)=10
 ;jmp 3
4: if rds(16)=14
 ;jmp 2
5: jmp 2
6: dsp "Out of
 Paper→→→";stp
7: prt A$
```

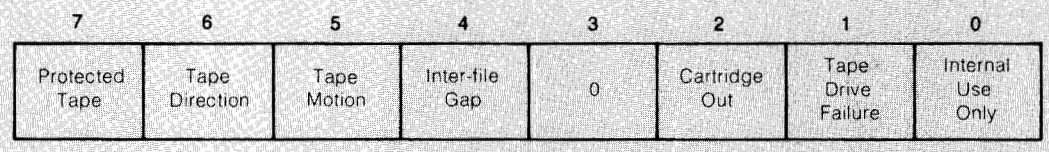
Fortunately, there's an easy way to isolate one bit of the status byte; this expression can be used to isolate bit 1: **int(n/2)mod 2** The number returned is either 0 or 1, reflecting the state of bit 1.

Here's a program segment that's equivalent to the one shown above ◗

```
0: int(rds(16)/
 2)mod2→A
1: if A=1;dsp
 "Out of Paper→→
 →";stp
2: prt A$
```

Tape-Drive Status Bits

The status bits available with the internal tape drive are shown below.



- Bit 0 - Is for internal use only.
- Bit 1 - Is 1 when a tape drive (hardware) failure occurs. Check the tape and then repeat the tape drive operation to verify the failure.
- Bit 2 - Is 1 when a cartridge is not loaded.
- Bit 3 - Is always 0.
- Bit 4 - Is 1 whenever the tape is positioned at an inter-file gap (between files). Bit 4 is usually 1, except when the tape is moving.
- Bit 5 - Is 1 whenever the tape is moving.
- Bit 6 - Is 0 to indicate forward tape movement and 1 to indicate reverse tape movement.
- Bit 7 - Is 1 whenever the tape is protected (RECORD slide).

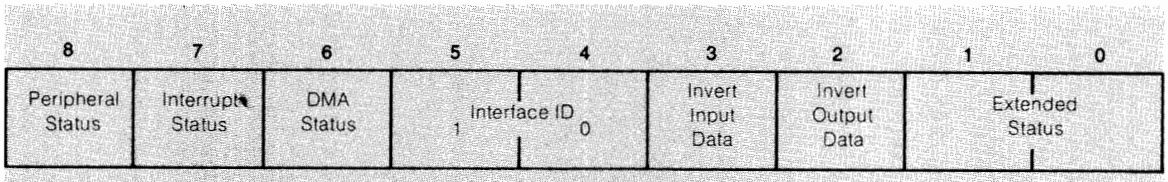
Tape Drive Status Bits

Here is a program sequence that checks for a protected tape before recording data. If bit 7 is 1 (decimal 128), "◀--Protected Tape!" is displayed.

```
7: if rds(1)<128
 ;jmp 2
8: fmt b,"--Prot
 ected Tape!";
 wrt 0,0;stp
9: rcf 5,A[L,P]
```

Interface Status

The 98032A Interface has nine status bits which can be monitored using read status:



- Bits 0, 1 and 8 - Indicate states of optional peripheral status-input lines.
- Bits 2 and 3 - Indicate states of logic levels preset on the 98032A.
- Bits 4 and 5 - Are preset to 0 and 1, respectively, on the 98032A.
- Bits 6 and 7 - Indicate operating states on the interface card. DMA (direct memory access) and interrupt functions are usable only with an Extended I/O ROM.

98032A Interface Status Bits

Refer to the 98032A manual for complete details on status meanings and status-input lines in use.

The 98032A Option 066 Interface Card uses bit 8 to indicate when the HP 9866B Printer is out of paper. The Peripheral Status bit remains at 1 (decimal 256) except when the printer is out of paper. Here is a program segment that checks for a 1 at bit 8 before sending data to the printer.

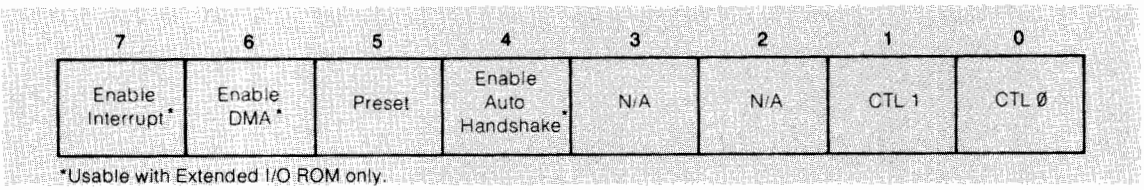
```
4: if rds(6)<257
 ;jmp 2
5: dsp "9866B
 Out of Paper";
 stp
6: wrt 6,A$,B
```

The Extended I/O ROM permits using additional parameters in the read status function, enabling other bytes of status information to be read from some interface cards. Refer to the Extended I/O Programming Manual and the interface installation and service manual.

The Write Control Statement

wtc select code ; expression

This statement outputs a binary number to control functions on most interface cards. One number is allowed with each statement. The available bits and their meanings for the 98032A Interface are shown below.



98032A Interface Control Bits

Control bits 0, 1, and 5 are used to drive interface output lines CTLØ, CTL1, and Preset. CTLØ and CTL1 are optional peripheral control lines, while Preset is used to initialize the peripheral to its power-up state. A preset signal is automatically given when the calculator is switched on or when (RESET) is pressed. The interface ignores bits 2 and 3. Bits 4, 6, and 7 are usable only when the Extended I/O ROM is in use. See the interface manual and Extended I/O Programming Manual for more details.

Chapter 4
HP Interface Bus

This chapter describes how to control and exchange data with instruments via the HP Interface Bus (HP-IB). Also included here is a brief description of the HP-IB and the 98034A Interface Card. For more information on the bus card, refer to its installation and service manual.

The General I/O ROM operations described in Chapters 2 and 3 are used to control each instrument via the HP-IB. You should be familiar with those operations before continuing in this chapter.

Overview of the HP-IB

The HP Interface Bus has a serial-byte bus structure which permits bi-directional communication between many instruments. When a controller such as a calculator is used, up to 14 additional HP-IB compatible devices can be controlled via one interface card.

Instruments can be controlled or programmed and data can be transmitted between devices on the bus. This is possible since each instrument connected to the bus has the potential of being a **talker** (send data) or a **listener** (receive data). Each instrument has a unique talk and/or listen address by which a **controller** communicates with the instrument. A unique handshake technique allows the communication to take place at a speed determined only by the specific instruments being addressed. Slower devices will not slow down the communication speed of the bus when they are not addressed.

In addition to the talker, listener, and controller functions, one device can be assigned the role of **system controller** on the bus. This instrument communicates with every other instrument and can halt and reset all bus operation at any time. The calculator is normally set to be the system controller; the function is enabled on the 98034A Interface Card.

Bus Messages

A common set of bus messages are used to transmit all data and control instructions between instruments. The bus messages used with the General I/O ROM are listed briefly here.

HP-IB Messages

Message Name	Description
Data	Transfers data and control information between instruments. To input data, use read statements or the read binary function. To output data, use write or write binary statements.
Remote	Sets all instruments for remote operation, enabling control via the bus. The Remote message is sent whenever the calculator is swiched on or [RESET] is pressed.
Abort	Halts all bus operation and returns control to the calculator. Press [RESET] to send this message.

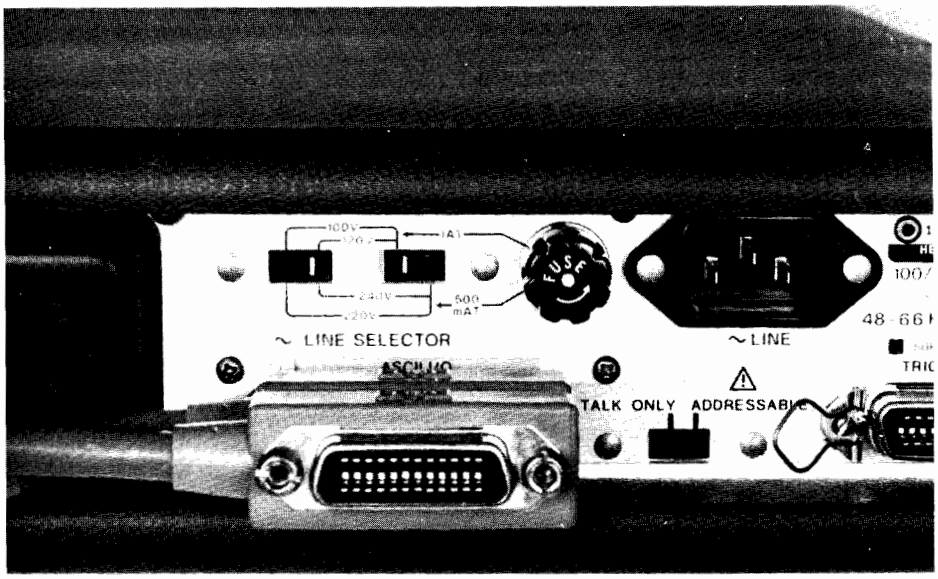
The Data message usually contains a list of talker and listener addresses and is followed by a string of characters representing data or other instructions to the assigned listener(s). The General I/O ROM, however, automatically generates the Data message to communicate between the calculator and the instrument specified by an address parameter (described later). So the General I/O ROM permits control of one instrument at a time on the bus.

When an Extended I/O ROM is in use, many other bus messages are available, enabling complete control of bus functions; refer to the Extended I/O Programming Manual for details.

The HP-IB Card

The HP 98034A Interface provides HP-IB capability for the HP 9825A Calculator. The bus card buffers all data and control messages between the calculator and instruments on the bus. The interface is preset to respond to select code 7.

Each instrument on the bus is connected through a 24-wire cable with a piggy-back connector on each end. Cables are available in 1, 2, and 4 meter lengths. Total cable length for a system can be up to 20 meters. The next photo shows two bus cables connected to an HP 3490A Multimeter.



Connecting Bus Cables

HP-IB Addresses

The General I/O ROM provides simplified control of instruments via the HP-IB by using a select-code parameter containing a three- or four-digit integer. The first one or two digits specify the bus card select code, while the last two digits represent the address of the instrument on the bus.

Instruments having HP-IB capability are assigned unique 7-bit ASCII characters for talker and listener addresses.[1] A controlling instrument, such as the calculator, uses the address characters to indicate which instrument is to talk (send data) or listen (receive data). For example, here are the addresses usually assigned to some instruments:

Instrument	HP-IB Address	
	Talker	Listener
98034A Interface	U	5
3490A Multimeter	V	6
9871A (Opt. 001) Printer	A	!
59309A Digital Clock	P	0

[1]Bus addresses for most devices can be changed, if needed; see the manual furnished with each instrument for details.

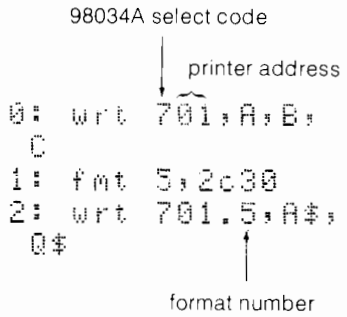
Now, using the ASCII table in the Appendix, convert the five least-significant bits of each character's binary form to a decimal value:

	Address	
Instrument	Character	5-bit Value
98034A Interface	U	21
	5	21
3490A Multimeter	V	22
	6	22
9871A Printer	!	Ø1
	A	Ø1
59309A Clock	P	16
	Ø	16

Notice that the 5-bit value for talker-listener instruments is the same number.

These numbers are used as the HP-IB address code in select-code parameters of General I/O operations. The HP-IB address code must always contain two digits; if the 5-bit value is a one-digit number (e.g., 9), a leading zero must be used (e.g., Ø9).

As examples, these write statements are addressed to a 9871A Printer via a bus card set to select code 7 ◗



This addressing method permits using all appropriate General I/O operations via the HP-IB. Typical example programs and sequences are shown on the following pages.

Controlling Listeners and Talkers

Instruments designated as listeners on the bus are controlled by using write and write binary statements. The address-code parameter just described must be used in each I/O operation.

Here is a short program which prints a listing of r-variables using a 9871A (Opt. 001) Printer. The printer bus address is set to "!" (address code 01). A sample printout and analysis of the program follow.

```
0: 0→A→X;10→B;
 20→C
1: fmt 5/,30x,
 "Data Register
 Listing",/;wrt
 701
2: fmt 3"ΔΔΔΔΔΔΔ
 Reg. ΔΔΔΔΔConten
 ts ΔΔΔΔ",/;wrt
 701
3: fmt f.0,e18.8
 ,f.0,e18.8,f.0,
 e18.8
4: wrt 6,"
 r",A,rA,"
 r",B,rB,"
 r",C,rC
5: A+1→A;B+1→B;
 C+1→C;X+1→X
6: if X=5;0→X;
 wrt 701
7: if A<=9;jmp -
 3
8: fmt 5/;wrt
 701
9: end
```

```
                    Data Register Listing

Reg.     Contents          Reg.     Contents          Reg.     Contents

r0    0.00000000E 00       r10   3.44827586E-01       r20   5.00000000E-01
r1    0.00000000E 00       r11   5.00000000E-01       r21   4.76190476E-01
r2    0.00000000E 00       r12   8.33333333E-01       r22   4.54545455E-01
r3    3.33333333E 00       r13   7.69230769E-01       r23   4.34782609E-01
r4    2.50000000E 00       r14   7.14285714E-01       r24   4.16666667E-01

r5    2.00000000E 00       r15   6.66666667E-01       r25   4.00000000E-01
r6    1.66666667E 00       r16   6.25000000E-01       r26   3.84615385E-01
r7    1.42857143E 00       r17   5.88235294E-01       r27   3.70370370E-01
r8    1.25000000E 00       r18   5.55555556E-01       r28   3.57142857E-01
r9    1.11111111E 00       r19   5.26315789E-01       r29   3.44827586E-01
```

Here is a brief analysis of the program:

- Line 1 – Causes the printer to advance paper five lines and print the program title. Notice that the title is centered on the paper by sending a block of spaces before the title.
- Line 2 – Causes the column headings to be printed. Here, spacing is achieved by including spaces (ΔΔ) within the text format specs.

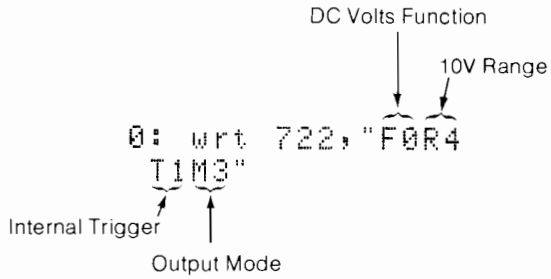
- Lines 3 and 4 – Specify the form of each table entry and which numbers (variables) are printed in each line of the table. The magnitude of each width (w) parameter in the format statement (line 3) was selected to position the corresponding table column under the appropriate heading.
- Line 5 – Increments program counters.
- Line 6 – Causes the printer to space one line after each five lines printed.
- Line 7 – Determines the maximum number of table entries.
- Line 8 – Causes the printer to space five lines.

As another example, the HP 3490A Multimeter can be connected via the bus and controlled by using strings of ASCII characters. Here is a list of control characters:

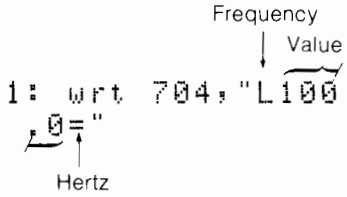
HP 3490A Control Characters

Char.	Function	Char.	Function
R	Range Program Identifier	T	Trigger Source Program Identifier
1	10,000 kΩ; Test 7	0	Internal Sample Rate
2	1,000 kΩ; 1000 V; Test 6	1	Immediate Internal
3	100 kΩ; 100 V; Test 5	2	Next External Trigger
4	10 kΩ; 10 V; Test 4	3	None
5	1 kΩ; 1 V; Test 3	M	Mode of Operation Program Identifier
6	.1 kΩ; 1 V; Test 2	0	Addressed Multi with No Output
7	Autorange; Test 1	1	Addressed Multi with Output
F	Function Program Identifier	2	Addressed Single with No Output
0	DC Volts	3	Addressed Single with Output
1	K Ohms	4	Interrupt Multi with No Output
2	AC Volts	5	Interrupt Multi with Output
3	Test	6	Interrupt Single with No Output
S	Sample/Hold Program Identifier	7	Interrupt Single with Output
0	Sample/Hold Off	E	Execute Mode of Operation Program
1	Sample/Hold Off		
2	Track/Hold		
3	Acquire/Hold		

The line on the right shows one method of setting 3490A range, function, etc., and then initiating a data sample. A read statement could be used to input the resulting data.



Here is a line which sets an HP 3330A Synthesizer to an output frequency of 100.0 Hz. Its listen address is "$" (decimal code 04).



Sometimes it may be necessary to program a device using a variable stored in the calculator. Perhaps the variable contains the desired output frequency or amplitude for a signal source. This example outputs the same characters as line 1 above. The data spec f.1 suppresses leading spaces, which the 3330A cannot accept.

```
2: fmt "L",f.1,
 "="
3: wrt 704,A A = 100.0
```

Data Input

For most applications, read statements and the free-field format are used to input data via the HP-IB. Many devices output leading non-numeric characters in data messages; format statements must be referenced to read those characters. Chapter 2 describes the data and edit specs usable with format statements.

Examples best illustrate the technique for receiving data via the bus. For example, the HP 3490A Multimeter may send a data message of this form when programmed for DC volts and the 10V range (Δ indicates a space):

NΔDC+083462E−4 CR LF

By using the sequence on the right, the calculator skips the four leading non-numeric characters and reads the numeric portion of the string.

```
5: fmt 4x,f
6: red 722.8,A
```

If the String ROM is in use, either of these sequences will input the same number shown above. The first sequence has the advantage of retaining all characters in the input string; in either case the leading characters can be checked later in the program. See the String Variables Programming Manual for more information.

```
7: dim A$[20]
8: fmt c16
9: red 722,A$
10: val(A$[5])→A
```

```
7: dim A$[4]
8: fmt c4,f
9: red A$,A
```

The b data spec can be used to input non-numeric characters. For example, suppose that this sequence is used to read the 3490A data string shown on page 41. Afterwards, variables A through E will contain ⧫

```
0: fmt 4b,f
1: red 722,A,B,
 C,D,E
```

A = 78 (N)
B = 32 (Δ)
C = 68 (D)
D = 67 (C)
E = 8.3462

Now consider this more-complex data message transmitted from an HP 3570A Network Analyzer:

−Ø34.48,−Ø88.93 (CR) (LF)

This sequence can be used to input and print the readings. The 3570A talker address is "A" (indicated by decimal code 01).

```
6: fmt ;fxd 2
7: red 701,A,P
8: prt "Amplitud
 e=",A,"Phase=",
 P
```

Here is a printout ⧫

```
Amplitude=-34.48
Phase=    -88.93
```

As a final example, here is a program which inputs, stores, and computes the average of 50 data samples taken using a 3490A Multimeter.

```
0: dim A$[50,
 20];0→A;1→I→N
1: wrt 722,"F0R6
 T1M3"
2: red 722,A$[I]
3: wrt 722
4: if (I+1→I)<51
 ;jmp -2
5: A+val(A$[N,
 5])→A
6: if (N+1→N)<51
 ;jmp -1
7: prt A/50
8: end
```

- Line 0 – Sets up a 50-element string array and initializes three variables.
- Line 1 – Programs 3490A remote controls and instructs it to take a data sample.
- Line 2 – Inputs the data sample into a string array element.
- Line 3 – Instructs the 3490A to take another data sample.
- Line 4 – Exits the data input loop when 50 samples are stored.
- Lines 5 - 7 – Compute and print an average value from the data.

Interface Status Bits

As described in Chapter 3, the read status function is used to return status information from a specified interface card. These 98034A Interface status bits can be read using the General I/O ROM:

7	6	5	4	3	2	1	0
Service Request	Controller Active	Talker Active	Listener Active	System Controller Set	1	Serial Poll Set	EOI

- Bit 0: Is 1 when the EOI (end of data) line has been set true. The bit is cleared via an rds function.
- Bit 1: Is 1 when the Serial Poll function is set.[1]
- Bit 2: Is always 1.
- Bit 3: Is 1 when the System Controller switch is enabled on the 98034A Interface Card.
- Bit 4: Is 1 when the calculator is an active listener.
- Bit 5: Is 1 when the calculator is the active talker.
- Bit 6: Is 1 when the calculator is an active controller.
- Bit 7: Is 1 when an instrument has sent a Require Service message.[1]

98034A Interface Status Bits

These interface status bits should not be confused with the bus messages Status Byte and Status Bit[1], which transfers status information on the bus. For examples using the read status function, refer to Chapter 3.

Although the calculator is normally the System Controller in an HP-IB system, the function can be disabled via a switch on the 98034A Interface Card. Bit 3 of the interface status byte is logical 1 when the function is set and 0 when the function is disabled.

When the calculator is not the System Controller, it must be addressed (from the System Controller) to talk, listen, or take active control; the bus message Pass Control is used to transfer control between devices. When the calculator is not in active control, it must monitor interface status bits 4 through 7 to determine when it has been addressed to talk, listen, or take active control.

[1]These functions and messages are enabled by using an Extended I/O ROM. See the Extended I/O Programming Manual for details.

When the read status function indicates that the calculator has been addressed to talk (bit 5 is logical 1), it can branch to an appropriate write-type operation to send a Data (output) message. When the calculator is addressed to listen (bit 4 is logical 1), it can execute an appropriate read-type operation to accept a Data (input) message. After executing each I/O operation, the calculator should then return to monitor interface status until it's addressed to talk or listen again.

When the calculator is addressed to talk or listen, the write or read operation must specify device address code 31 (e.g., `wrt 731,...` or `red 731,...`). If any other address code is specified when the calculator is not in active control of the bus, an error message will indicate that the calculator cannot address the bus when it is not the active controller.

When the calculator is addressed to take active control (bit 6 is logical 1), it can perform any appropriate bus operations until the System Controller sends the Abort message. When the Extended I/O ROM is installed, the calculator can pass control back to the System Controller or to another appropriate device by using the pass control (`pct`) statement.

A more complete discussion of calculator operation when it is not the active controller is in the Extended I/O Programming Manual.

Appendix

Binary Coding and Conversions

Binary is a base 2 number system using only 1s and 0s. By giving the 1s and 0s 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 1s 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. ASCII is an eight-bit code, containing seven data bits and one parity bit. The General I/O ROM 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 page 48.

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 the BCD 12-bit word 010000110110 to decimal:

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

The decimal equivalent number is found by breaking up the word into 4-bit bytes (starting from the right) and converting the bytes 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

Select Codes

The recommended select-code assignments for a 9825A Calculator system are listed below. The HP calculator peripherals and interfaces listed are preset at the factory to the indicated select code.

Factory Set Select Codes

Select Code	Assignment	HP Peripheral Device
0	Calculator Keyboard and Display	———
1	Calculator Tape Drive	———
2	Paper Tape Punch	9884A*,98032A Interface
3	Paper Tape Reader	9883A*,9863A*,98033A Interface
4	Digitizer	9864A*
5	Plotter	9862A*
6	Printer	9866B*,9871A*
7	HP Interface Bus	98034A Interface
8	Mass Memory	9885A*
9 through 15	Unassigned	Special or Duplicate Peripherals
16	Calculator Printer	———

*These peripherals should be ordered with Option 025.

ASCII Character Codes

ASCII Char.	EQUIVALENT FORMS Binary	Octal	Dec
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
HT	00001001	011	9
LF	00001010	012	10
V_{TAB}	00001011	013	11
FF	00001100	014	12
CR	00001101	015	13
SO	00001110	016	14
SI	00001111	017	15
DLE	00010000	020	16
DC_1	00010001	021	17
DC_2	00010010	022	18
DC_3	00010011	023	19
DC_4	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
space	00100000	040	32
!	00100001	041	33
"	00100010	042	34
#	00100011	043	35
$	00100100	044	36
%	00100101	045	37
&	00100110	046	38
'	00100111	047	39
(	00101000	050	40
)	00101001	051	41
*	00101010	052	42
+	00101011	053	43
,	00101100	054	44
-	00101101	055	45
.	00101110	056	46
/	00101111	057	47
Ø	00110000	060	48
1	00110001	061	49
2	00110010	062	50
3	00110011	063	51
4	00110100	064	52
5	00110101	065	53
6	00110110	066	54
7	00110111	067	55
8	00111000	070	56
9	00111001	071	57
:	00111010	072	58
;	00111011	073	59
<	00111100	074	60
=	00111101	075	61
>	00111110	076	62
?	00111111	077	63

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

ASCII Char.	EQUIVALENT FORMS Binary	Octal	Dec
`	01100000	140	96
a	01100001	141	97
b	01100010	142	98
c	01100011	143	99
d	01100100	144	100
e	01100101	145	101
f	01100110	146	102
g	01100111	147	103
h	01101000	150	104
i	01101001	151	105
j	01101010	152	106
k	01101011	153	107
l	01101100	154	108
m	01101101	155	109
n	01101110	156	110
o	01101111	157	111
p	01110000	160	112
q	01110001	161	113
r	01110010	162	114
s	01110011	163	115
t	01110100	164	116
u	01110101	165	117
v	01110110	166	118
w	01110111	167	119
x	01111000	170	120
y	01111001	171	121
z	01111010	172	122
{	01111011	173	123
|	01111100	174	124
}	01111101	175	125
~	01111110	176	126
DEL	01111111	177	127

Decimal Key Codes

KEY	CODE UNSHIFT	CODE SHIFT
A	97	225
B	98	226
C	99	227
D	100	228
E	101	229
F	102	230
G	103	231
H	104	232
I	105	233
J	106	234
K	107	235
L	108	236
M	109	237
N	110	238
O	111	239
P	112	240
Q	113	241
R	114	242
S	115	243
T	116	244
U	117	245
V	118	246
W	119	247
X	120	248
Y	121	249
Z	122	250
! 1	49	177
" 2	50	178
# 3	51	179
$ 4	52	180
% 5	53	181
& 6	54	182
@ 7	55	183
(8	56	184
) 9	57	185

KEY	CODE UNSHIFT	CODE SHIFT
' 0	48	176
['	123	251
0	78	206
1	79	207
2	80	208
3	81	209
4	82	210
5	83	211
6	84	212
7	85	213
8	86	214
9	87	215
.	88	216
,	89	217
=	61	189
→	125	253
CLEAR	18	146
ENTER EXP	96	224
(	40	168
)	41	169
/	47	175
*	42	170
−	45	173
+	43	171
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f0	65	193
f1	66	194
f2	67	195
f3	68	196
f4	69	197
f5	70	198
f6	71	199
f7	72	200
f8	73	201
f9	74	202

KEY	CODE UNSHIFT	CODE SHIFT
f10	75	203
f11	76	204
PRT ALL	19	147
REWIND	2	130
STEP	24	152
↑	16	144
↑	17	145
DELETE	9	137
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FETCH	28	156
ERASE	29	157
LOAD	31	159
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→	15	143
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RUN	12	140
STORE	13	141
STOP	1	129
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;	59	187
↑	94	222
< ,	44	172
> .	46	174
: ?	63	191
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General I/O Syntax

Syntax Conventions

Brackets [ ] - Items within brackets are optional.

Dot Matrix - Items in dot matrix must appear as shown.

Expression - A constant (like 16.4), a variable (like X or B[8] or r3), or an expression (like 8↑4 or 6<A +B).

Select code format - **cc[dd[ee]][.f]**

cc = device or interface select code.

dd = optional HP-IB address code (must be two digits).

ee = optional HP-IB extended address code (Extended I/O ROM only)

.f = format number, for read and write only.

Text - A series of characters within quotation marks.

Variable - A simple variable (like A or Q), an array variable (like E[5]), an r-variable (like r12), or a string name (like A$).

... - Dots indicate that successive parameters are allowed. Be sure that a comma precedes each successive parameter.

Conversion Statement

conv [code$_1$, code$_2$[, code$_3$, code$_4$][, ...]]

Sets up a character conversion table for read and write statements. Ten pairs of ASCII-decimal codes are allowed. See page 25.

Format Statement

fmt[format no.][spec$_1$[, spec$_2$...]]

Lists data and edit specifications for read and write statements. All numeric parameters must be integer constants. See pages 10 thru 24.

List Statement

list[#select code]

Output program listings to external devices. See page 25.

Read Statement

red select code [, format no.] ; variable$_1$[; variable$_2$...]

Input data and string variables, using either free-field or format specs. See page 7.

Read Binary Function

rdb (select code)

Input a single 16-bit character and return a decimal number in range: −32768 to 32767. See page 28.

Read Status Function

rds (select code)

Input one byte of status information and return a decimal equivalent code. See page 29.

Write Statement

wrt select code [, format no.][; expression or text$_1$[; expression or text$_2$...]]

Output data using free-field or format specs. See page 5.

Write Binary Statement

wtb select code ; expression or text$_1$[; expression or text$_2$...]

Output single 16-bit characters. See page 27.

Write Control Statement

wtc select code ; expression

Output a single binary number to control functions or lines on an interface card. See page 33.

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General I/O Error Messages

error G1 Incorrect Format Numbers:

- Format number in format statement not in range of $0 \leq n \leq 9$.
- Referenced format number not executed.

error G2 Referenced Format Statement has an error:

- Incorrect format spec.
- Numeric overflow in format statement.

error G3 Incorrect I/O Parameters:

- Parameter not a number or a string.
- Negative parameter with f z numeric spec.
- Numeric parameter with c edit spec.
- Binary parameter not in range of $-32768 \leq n \leq 32767$.
- More than one parameter for read binary or read status function.
- Missing or non-numeric parameter for write control statement.

error G4 Incorrect Select Code:

- Select code is non-numeric or greater than 4 digits.
- Select code is greater than 16 for read status.
- Select code is not in range from 0 through 16.
- Select code 1 allowed only for read status.
- HP-IB address code not in range from 0 through 31.
- Read from select code 0 not allowed.

error G5 Incorrect Read Parameter:

- Constant in read list.
- String not filled by read operation.
- Numeric parameter references c format spec.

error 66 Incorrect Parameter in Conversion Statement:

- More than 20 parameters.
- Odd number of parameters.
- Non-numeric parameter.
- Parameter not in range of $0 \leq n \leq 127$.

error 67 Unacceptable Input Data:

- More than one decimal point or "E" read.
- 511 characters read without a LF.
- "E" with no leading digit.
- More than 158 numeric characters read.

error 68 Peripheral Device Down:

- Incorrect status bits – device not ready or power is off.
- (STOP) cancelled operation.

error 69 Interface Hardware Problem:

- Improper HP-IB operation.
- Empty I/O slot.
- Select code does not match interface card (e.g., `wrt 711` when a 98032A is set to 7, or `wrt 6` when 98034A is set to 6.
- Write Control addressed to a 98034A HP-IB Card.