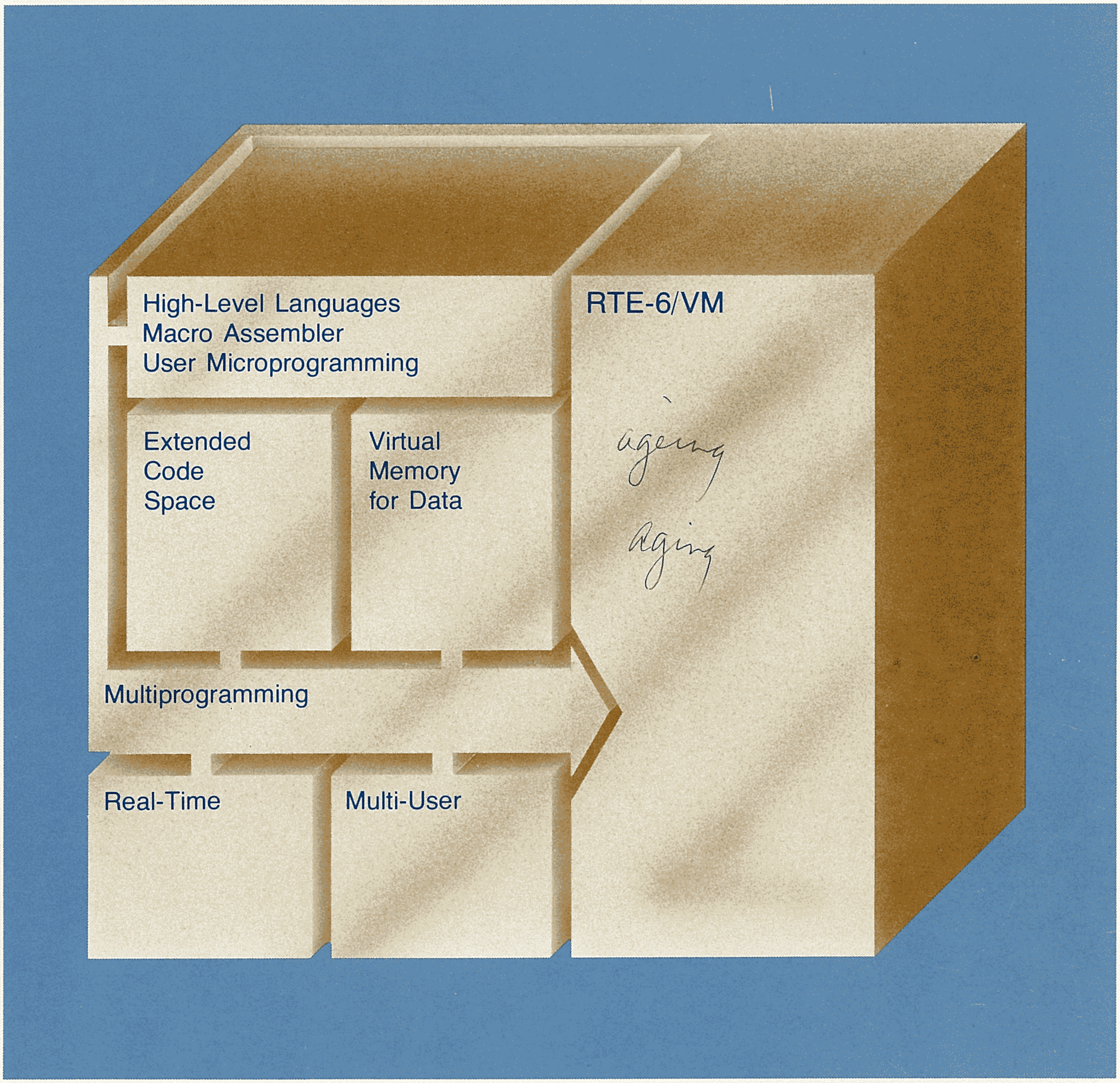
HEWLETT PACKARD

RTE-6/VM Debug Subroutine

Reference Manual



RTE-6/VM
Debug Subroutine
Reference Manual

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PRINTING HISTORY

The Printing History below identifies the Edition of this Manual and any Updates that are included. Periodically, Update packages are distributed which contain replacement pages to be merged into the manual, including an updated copy of this Printing History page. Also, the update may contain write-in instructions.

Each reprinting of this manual will incorporate all past Updates, however, no new information will be added. Thus, the reprinted copy will be identical in content to prior printings of the same edition with its user-inserted update information. New editions of this manual will contain new information, as well as all Updates.

To determine what software manual edition and update is compatible with your current software revision code, refer to the appropriate Software Numbering Catalog, Software Product Catalog, or Diagnostic Configurator Manual.

First Edition .... Dec 1981

Preface

This manual references DBUGR, the debugger for MLDSB, the debugger for LOADR, and the debugger for MLLDR. Most commands are the same for both versions of the debugger. Commands that apply to only one version will be so noted with a reference to LOADR or MLLDR.

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Chapter 1
Introduction

DBUGR is a utility program for debugging programs run on HP 1000 series computers. It features:

* Symbolic or octal printout
* Symbol definition
* Register examination and change
* Cassette tape loading and verification (LOADR version only).
* Memory search
* Memory clear
* Breakpoints
* Map examination.
* Memory examinations and change in user partition and systems.

Operating Environment

DBUGR runs on any HP 1000 series computer equipped with DMS and teleprinter (or CRT) running the RTE-6/VM operating system. DBUGR itself is approximately 3.7K words in length including symbol table and excluding the breakpoint table. The user symbol table space is fixed at 50 words in length. Two locations are required for symbols of one or two characters, while three locations are required for symbols of three to six characters. The breakpoint table, which uses 50 words of memory, consists of 10 breakpoints of 5 words each.

Cassette tape operations are configured to dump to LU 4 and read from LU 5.

Loading and Using DBUGR

DBUGR must be loaded with the program to be debugged. This can be done in one of two ways. The first is to use the DB loader option. LOADR will set the primary entry point of the program to DBUGR and save the program's actual start address in DBUGR. For example:

```
RU,LOADR,,%PROG,,DB     or     RU,MLLDR,,%PROG,,DB
```

or:

```
RU,LOADR                or     RU,MLLDR
OP,DB                          OP,DB
RE,%PROG                       TR,/PROG
```

where /PROG contains:

```
M
RE,%PROG
END
```

Note that this is the only way that segment or path breakpoints can be made available.

The second method is for the program to call DBUGR directly by the following calling sequence:

```
    Assembly                          Fortran
    EXT DBUGR                         CALL DBUGR(lu#-optional
    JSB DBUGR                                     parameter)
    DEF RTN
    DEF lu# of console (optional)
RTN EQU *
```

For the MLLDR version, use MLSDB in place of DBUGR.

When the user's program begins execution, DBUGR takes control and prints START DBUGR on the optional console logical unit or, if not included, on the logical unit passed to DBUGR through the system subroutine LOGLU. At this point the user can initiate a debug operation. All debug operations are conducted at the Assembly Language level. A load map and assembly listing of the program is essential. If debugging a program written in a higher level language, a mixed listing of source and assembly is required. The Macro Assembler LIST MEDIUM option is most useful.

Controls

Controls, consisting of special characters and letters preceded with escape or ALTMODE, act as DBUGR commands. In the text that follows, escape will be denoted by \, carriage return by CR, control by CTRL, tab by TAB and line feed by LF. (CTRL-J is optional LF on 264x terminals.) Escape prints as a backslash (\) on a TTY or CRT. Some controls are:

```
/
!
\S
=
+
```

For multipoint terminals or terminals using driver DVR07, refer to Appendix D.

NOTE

> Some terminals do not print the first backslash after an escape (e.g., the 2640). The control "\U" will cause DBUGR to print two backslashes for each escape.

Expressions

An expression, which will be denoted in the text by the letter n, consists of one or more terms, combined by operators as in the following:

```
AA+10
```

Terms

A term may be a symbol (denoted in the text by the letter s), a number, or a special notation called a mark. The following are terms:

BB	A symbol is defined as a letter or a period followed by any number of letters, digits or periods. Only the first six characters are significant. For example: ABC A5 .B A.ZZZZZ .4 ... Each symbol may be assigned a value. The symbol and its value are equated by entries in the DBUGR symbol table. Values for symbols lie in the range of -32768 through 32767.
3775	An octal number.
386.	A decimal number. The decimal point is used to characterize the number as decimal rather than octal. A decimal point in a number other than as the last character is not meaningful.
. and *	Period and Asterisk are marks. When used as terms in an expression their value is equal to that of the current value of DBUGR's program location counter.
\Q	Esc-Q is a mark. It refers to the last quantity typed.

Operators

Legal operators are:

+	Add terms
Space	Add terms (this is manually faster than shifting and depressing the + key.)
-	Subtract term
,	Inclusive OR terms (inclusive OR is used to selectively set individual bits within a word).

Operators are discussed in more detail in Appendix A.

Conventions Followed in the Text

1. What you input to DBUGR is underlined in the examples. When you must enter an underline, the example shows an underline with a blank above it.

2. Use of a control that does not cause print-out is denoted by brackets ([]). These will not be underlined.

3. All values referenced in the text are octal unless otherwise noted.

4. Vertical and horizontal spacing shown in the examples is not exactly as it appears on a teletype or CRT printout.

Limitations

DBUGR reads and interprets each character as it is entered so that many commands may be invoked by a single keystroke. Since one character is read at a time, it is possible for the user to get ahead of DBUGR and get a system prompt. When this happens the user should increase the priority of the program being debugged with the PR command. Alternatively, through use of the \U command, DBUGR can accept a continuous string or line of characters as would be sent from a 264x terminal by a soft key, cartridge tape unit, or a Multipoint 264x terminal using driver DVR07.

Chapter 2
Output Modes

Output Modes

Information can be displayed in one of four modes:

1. Symbolic instructions

2. Numeric constants

3. Address pointers

4. ASCII characters

Although a printing mode normally remains in effect until changed, it is possible to either:

a. momentarily invoke a different mode for the display of only one number, or

b. temporarily invoke a different mode for a series of examinations until a carriage return is entered.

Printout as Symbolic Instructions

DBUGR is in symbolic mode when it is loaded.

In symbolic mode the contents of a memory location are printed as symbolic instructions; the operation codes are represented as mnemonics. The address field of one-word memory reference instructions will be printed as octal numbers with the page number merged with the page offset. Only the first word of multi-word instructions will be interpreted.

It is important to note that in symbolic mode every location is printed as a symbolic instruction whether that location contains an instruction, data, or an address. The bit pattern in memory is simply interpreted as an instruction. For example, the octal value 1767 would appear in memory as:

```
bit 15                          6                      0
  +------------------------------------------------------+
  | 0   0   0   0   0   0   1   1   1   1   1   1   0   1   1   1 |
  +------------------------------------------------------+
```

Notice that bits 6 through 15 correspond to the bit pattern for the ALF instruction. The lower 6 bits are similarly treated as instructions. The printout appears as:

```
ALF,CLE,ALF
```

Also notice that not all shift rotate instructions are defined. In those cases DBUGR will print the valid opcodes merged with the remaining bits. For example, the octal value 1747 will be printed as ALF,CLE,7.

DBUGR's symbol table does not contain instructions referencing the overflow register, therefore overflow instructions will be printed as I/O instructions with a select code of 1.

The operand field for I/O and double shift instructions will be printed correctly except when the operand is zero, in which case a blank is printed instead of a zero. Therefore STF 0 will be printed as STF, and RRL 16 (actual operand is 0) will be printed as RRL.

"I" and "C" are special symbols in DBUGR's symbol table with the octal values of 100000 and 1000, respectively. Therefore 100000 and 1000 will be reverse assembled as I and C. I means the reference is indirect; C means the reference is on the current page.

From this discussion, it is obvious that we must know whether we are looking at data or instructions. It is also obvious that it is desirable to be able to print data or address words as octal numbers. DBUGR provides this capability.

Printout as Numeric Constants

We can either momentarily change the printing mode to octal so the last item printed will be reprinted as octal, with subsequent printouts continuing in the master mode; or we can change the master mode to octal so that all subsequent printouts will be in octal.

Conversely, if we change the master mode to octal, we have the capability of momentarily switching back to symbolic; it works both ways. The examples below demonstrate printing modes. In these examples the following controls are used:

n/	Prints the contents of memory location n. These contents can be modified at this point, but that is discussed later.
\C	Set master print mode to numeric constant. Remember, C means constant.
=	Print the last quantity (typed by either the user or DBUGR) as a numeric constant. This is a momentary mode change.
\=	Same as =, except constant mode remains in effect until a carriage return. This is a temporary mode change.
\S	Set master print mode to symbolic instruction. Remember, S means symbolic.
!	Print the last quantity typed as a symbolic instruction. This is a momentary mode change.
\!	Same as !, except symbolic mode remains in effect until a carriage return. This is a temporary mode change.

Changing the Radix of Numeric Printout

An interesting feature of DBUGR is that the numeric output (in any mode) does not have to be octal. The radix of output values can be from 2 to 33. Thus, it is possible to print data as a decimal value or examine memory in hexadecimal. If the radix is decimal, numbers are followed by a period. You can change the output radix by using the control n\R. DBUGR interprets all values as 16 bit unsigned numbers, regardless of radix.

n\R where n can be any decimal value from 2 to 33 (or octal value from 2 to 41. Remember, R means radix.

For example:

```
2420/  ADA 2745  \C [LF]               Select numeric constant
                                       master mode
2421/  3004 2\R  [LF]                  Select binary output
10100010010/ 10000010000 10\R [CR]     Select octal output*
\S   [LF]                              Select symbolic master mode
2423/  JMP 2714,I  [LF]
2424/  SZA  [LF]
2425/  JMP 2714,I  2\R  [LF]           Select binary output
        .
        .
        .
```

*The radix could have been specified in decimal as 8.\R.

Note that numeric input is always in either octal or decimal.

```
10100010110/ JMP 10111001101,I 20\R [CR] Select hexadecimal output
\S [LF]                                  Select symbolic master mode
517/ JSB 331,I [LF]
518/ CLA,SSA,SLA,SZA  \C [LF]            Select constant master mode
519/  51A  [LF]
51A/  9B3E 10\R  [CR]                    Select octal output
2471/  3004  10.\R [LF]                  Select decimal output
1338./ 1040.  [LF]
1339./  44464.  [LF]
1340./ 1026. [LF]
```

Alphanumeric (ASCII) Printout

It may be necessary to examine alphanumeric information. If so, DBUGR allows us to change the printing mode so that the contents of each memory location are printed as two ASCII characters. In this mode DBUGR will interpret the 16 bits as two 8-bit ASCII codes, whether the memory location contains data, an instruction, or an address. The controls are:

\H	Sets master printing mode to ASCII characters.
'	Prints the last quantity typed as two ASCII characters. Then prints a double quote.
\\'	Same as ', except ASCII mode remains in effect until a carriage return.

Remember, H means Hollerith.

Study the following example carefully:

```
2514/ 115762            \H [LF]  Select ASCII printout
2515/PV"=50126          ' PV"  [LF]
2516/NE"=47105          ' NE"  [LF]
2517/@."=40056          ' @."  [LF]
2520/-"=2655            ' -"   [LF]
2521/*"=115452          ' *"   [LF]
2522/S"=2523            ' S"   [LF]
2523/-0"=126660         '-0"   [LF]
2524/ >"=115476         '>"    [LF]
2525/+0"=25460          '+0"   [LF]
.
.
.
2532/-"=2655            '-"    [LF]
2533/ "=12              '"     [LF]
2534/ "=5               '"     [LF]
2535/ *"=115452         '*"    [CR]
```

From an examination of the octal equivalents of the printed characters, several observations can be made:

1. A character will be printed only if the upper and/or lower 8 bits of a word contain bit patterns that represent legitimate ASCII characters.

2. If either 8-bit field does not represent an ASCII character, it is not printed. There is no way to determine whether a single printed character fell in the upper or lower half of the word without looking at the octal equivalent. At location 2522 above, only the lower half of the word converts to the character S.

3. If neither half word contains an ASCII code, but does contain binary information, nothing is printed (location 2534 above). If a non-printing ASCII character is encountered, DBUGR performs the function that ASCII code represents. For example, encountering a 007 causes the bell to sound, and encountering a 012 causes a line-feed.

Address Pointers

There is one more printing mode, It allows DBUGR to print a 16-bit memory location as an address pointer. Keep in mind that in HP 1000 computer programming, many words are set up to contain a full 15-bit address plus a bit to indicate direct or indirect use of that address. In the following code:

```
3000            LDA         POINT,I
                 .
                 .
3010 POINT      DEF         DATA
                 .
                 .
7000 DATA       BSS         1000
```

the DEF pseudo operation generates a full 15-bit address at location 3010. The address generated is that of the symbol DATA; i.e., 7000, and this address is used as a pointer by instructions such as the LDA at 3000 to access the data stored at DATA. The contents of location 3010 look like:

```
bit 15                                             0
   +-----------------------------------------------+
   |0  0  0  0  1  1  1  0  0  0  0  0  0  0  0  0| =7000
   +-----------------------------------------------+      8
```

Memory locations containing address words can easily be examined in numeric constant mode. In fact, if we switch to the printing mode that allows us to print the contents of memory locations as addresses, there appears to be no difference in output. The example below demonstrates the apparent identity. The control _ (underline) prints the last quantity typed in address pointer mode.

```
\C      [CR]
1510/   60247    _ 60247    [LF]
1511/   3004     _ 3004     [LF]
1512/   102000   _ 2000,I   [LF]
```

The two modes return almost identical results! What then is the use of address pointer mode?

Printing in address pointer mode is useful only in conjunction with another feature of DBUGR; i.e., the capability of associating symbols with numeric addresses.

Defining Symbolic Addresses in DBUGR

Remember that when a program is in memory for execution, all symbols associated with program locations at assembly time have been converted to absolute addresses; they are gone! As DBUGR maintains its own symbol table, we can associate arbitrary symbols with specific locations. This is useful because we may wish to see locations and address references printed as symbols rather than words.

Before we see how symbols are manipulated, it is necessary to learn how DBUGR sequences through a program. For example, to begin debugging at location 2500, we would type:

```
2500/
```

DBUGR will respond by typing the contents of location 2500 (assume we are in numeric constant print mode). The output would look like:

```
2500/  171572
```

If we strike LF or CTRL-J on a 264x, the next sequential location in memory is displayed:

```
2500/  171572 [LF]
2501/     723 [LF]
2502/    5241
```

Although it was not explicitly mentioned, in all previous examples advancing to the next line of print was accomplished by LF.

Obviously, DBUGR maintains a location counter similar to the P-Register of the computer, and LF is the control for sequentially examining memory. Later we will see that the contents of the memory location just printed can be changed before executing the LF.

If we wish to associate a symbol with the address 2500, we can type the following:

n<s: where n is an expression resulting in a 16-bit value and s is a symbol. The symbol is then said to be defined.

Thus, "less than" (<) is a control to designate a value, and "colon" (:) is a control to define a symbol.

```
2500<SYM:
```

will associate the symbol SYM with the address 2500.

In the following example, notice how symbols replace numeric notation after location 2500. Assume we are in numeric constant mode, and SYM has been defined as above.

```
2476/   126720   [LF]
2477/   115476   [LF]
SYM/    2734     [LF]
SYM+1/  115471   [LF]
SYM+2/  25460    [LF]
SYM+3/  126666   [LF]
  .
  .
  .
```

A strange thing happens after location SYM+10:

```
SYM+10/  165715   [LF]
2511/    7004     [LF]
2512/    77113
```

Except for symbols of one or two characters (for which the numeric offset has no limits), symbolic addresses are associated relative to a particular symbol for eight (octal 10) locations. If we wish to continue using symbolic addressing, we have to define another symbol:

```
SYM+130/    165715 [LF]
2631/ 7004  [CR]
2631/ SYM2: [LF]
SYM2+1/ 77113
```

Notice the use of CR above. Unlike LF it only returns us to the next print line; the location counter does not change. Actually it is generally not necessary to strike a CR before typing a new address or using a new control. You can continue on the same line.

For symbols of one or two characters, where the numeric offset has no limit:

```
2631<S:  [CR]
S+5000/ 7004 [LF]
S+5001/ 165715 [LF]
   .
   .
   .
```

This mode is useful with relocatable code where we might define a symbol for the origin of each module. The offsets would then be the same as those printed on the assembly listings.

Another form of symbol definition that would have been more efficient at location 2631 above is illustrated below:

```
SYM+130/   165715   [LF]
2631/      7004  SYM2:   [LF]
SYM2+1/    77113
```

When no value is explicitly designated for a symbol definition, the current value of the location counter is used.

Now let us look more closely at the printout in symbolic instruction mode (Column A of Figure 2-1). Notice that we may specify the address at which to begin printing by using its symbolic form:

	A SYMBOLIC INSTRUCTION	B ADDRESS POINTER	C OCTAL CONSTANT
SYM+1/	JSB 1471,I	<-15471,I	=115471
SYM+2/	JMP 1460	<-25460	=25460
SYM+3/	JMP SY+35,I	<-26666,I	=126666
SYM+4/	JSB 1454,I	<-15454,I	=115454
SYM+5/	CLA,CLE,INA,SZA,RSS	<-SYM+7	=2507
SYM+6/	CLE,SEZ,SSA	<-2120	=2120
SYM+7/	JMP 2716,I	<-26716,I	=126716
SYM+10/	JSB 1453,I	<-15453,I	=115453
SYM+11/	CLA,CLE,SSA,SZA,RSS	<-SY+13	=2513
SYM+12/	CLE,SEZ,SSA	<-2120	=2120
SYM+13/	JMP 2716,I	<-26716,I	=126716
SYM+14/	JSB 1762,I	<-15762,I	=115762
SYM+15/	CLA,CLE,SSA,RSS	<-SY+21	=2521
SYM+16/	2746	<-SY+115	=2746

Figure 2-1. Symbolic, Address Pointer, and Octal Constant

Notice that not only are the locations printed in symbolic form, but some addresses referenced by memory reference instructions also appear using the offset limits; i.e., 10 for multicharacter symbols or no limit (but >0) for one or two character symbols.

Referring to the octal printout in Column C, notice that the entire word is printed as an octal constant, even if that constant represents an address that can be represented symbolically, as at location SYM+7.

In symbolic instruction mode, symbolic addresses appear only if that word is a one-word memory reference instruction. Address pointers will not be printed symbolically. They will appear either as octal constants, as locations SYM+16 or as meaningless instructions as at location SYM+11.

A glance at Column B in Figure 2-1 immediately reveals that address pointer mode is the only mode that will print 15-bit addresses in symbolic form. Notice that the control <- is used to momentarily invoke address pointer mode. To set the master printing mode to address pointer, use the control:

\A Sets the master printing mode to address pointer. Remember A means address.

The control \ <- can be used to temporarily invoke address pointer mode until a carriage return is executed.

Deleting Symbols from the Symbol Table

Using the control \K will kill all symbol definitions that we have defined. Symbols defined by DBUGR remain. Remember K means kill.

CAUTION

Do not use the following to define address labels:

1. Instruction mnemonics; if a symbol is redefined, the original value is lost.

2. The letters C and I; these are defined as 1000 and 100000 octal, respectively.

3. Special Register Symbols.

Assigning a Symbol to an Address Just Printed

In addition to being able to define a symbol equal in value to a specific address or to the current value of the location counter, we can equate a symbol equal in value to an address just printed by DBUGR:

s& Defines symbol s equal in value to the address of the last quantity typed, if an instruction. If not an instruction, the operation is undefined (error U).

For example:

```
1476/    JMP 305 XFER&   [CR]
305/     SLA+17          [CR]     The symbol XFER is defined
XFER/    SLA+17          [LF]
XFER+1/  SLA+20
```

Print Momentarily in Master Mode

This section described how to print the last quantity typed in the master mode if you have just momentarily changed modes.

; Prints last quantity typed in master mode.

For example:

```
1700/ HLT 77 =102077 ;HLT 77 [CR]
1777/ 40502 'AB" ;40502
```

Chapter 3
Memory Examination and Modification

Examine Memory Only-Location Counter Does Not Change

We have already used two controls to examine memory locations:

n/ To open and print the contents of location n.

LF To open and print the contents of the next sequential location.

Actually these controls do more than print the contents of the memory location; they "open" the location for possible modification. Before we explore that possibility, let us look at some other controls for examining memory:

/ Opens and prints the contents of the location pointed to by the last quantity typed. The quantity typed is used as a 15-bit address, regardless of the printing mode.

For example:

```
2007/  20602  /  67  [LF] Opens and prints contents of 20602.

2010/  30501  /  115723   Opens and prints contents of 30501.
```

Notice that DBUGR's location counter does not change. We can continue sequential examination of memory simply by using LF.

\/ Opens and prints the contents of the location pointed to by the last quantity typed. Unlike /, the last quantity typed is interpreted as a memory reference instruction and only the 11-bit address field is used as the effective address. The location counter does not change.

\L Prints the contents of the next 16 sequential locations; the last printed location is left open.

n\L Same as the \L, the quantity n premanently replacing 16 as the number of locations listed.

For example:

```
5010/    ELA    5\L
5011/    ADA 2042
5012/    CMA,INA
5013/    SSA,RSS
5014/    JMP 3066
5015/    JSB 2076
```

Examine Memory and Set the Location Counter

The following two controls are similar to / and \/, but notice that the location counter is set to the address of the memory location being examined.

CTRL-I (TAB) (compare with /) — Opens and prints the contents of the location pointed to by the last quantity typed. This quantity is used as a 15-bit address pointer. DBUGR's location counter is changed to contain this address.

For example:

```
2312/    2031    [CTRL-I]     Location counter change
2031/    126313  [CTRL-I]     to 2031 then to 26313.
26313/   43734
```

\CTRL-I (\TAB) (Compare with \/) — Same as CTRL-I except that the last quantity typed is interpreted as an instruction and only the 11-bit address field is used as the pointer.

For example:

```
5002/   JMP  5007  \  [CTRL-I]    Location counter
5007/   SLB+56                    changes to 5007
```

Change the Contents of Memory

To change the contents of a memory location, simply open that location, then type the quantity desired followed by one of the controls discussed below. The quantity you type is designated by n.

Memory Change Controls

nCR n is the quantity that we want stored in the open location.
nLF The control that follows this quantity executes as
n^ previously described.

For example:

```
5010/ 1600    7777   [CR]   Contents of 5010 changed to 7777.
*/ 7777                     Verify by re-examining 5010.
```

Note that an asterisk is used to imply an address equal in value to the current value of the location counter. A period can be used in place of an asterisk.

```
5012/  27006  6655   [LF]   Contents of 5012 changed to 6655.
5013/  2060   ^             Verify by sequencing backward.
5012/  6655          [CR]
5012/  6655   44444  ^      Contents of 5012 changed to octal
5011/  7777   [LF]          44444.   Verify  by  sequencing
5012/  44444                forward.
```

IMPORTANT: The use of CR will close the currently open memory-register!

For example:

```
5010/  1600   7777  [CR] Contents of 5010 becomes 7777.
3333   [CR]              Attempt to change again, but 5010
*/ 7777                  still contains 7777.
```

Note that a period is used above to refer to an address equal in value to the current value of the location counter.

DBUGR provides a control for storing one or two ASCII characters in a word. It has the form s" where s is a symbol.

Type the ASCII input and the quote followed by any of the memory change controls discussed above:

```
1700/   20532  AB"    [CR]
*/   40502   'AB"
```

Only letters, digits, or the period, may be used; other characters, including blanks, are illegal. For these other characters, use the octal values given in Appendix E. If there are two characters, combine the octal values of the last byte and the right byte into one number

For example:

```
35012/   0   STA 1,I   [CR]
36012/   STA 1,I
```

The next two controls allow us to store a new address in an open memory location and then open and examine the contents of the location pointed to by that address:

n% Stores the quantity n in the currently open memory location; then opens and prints the contents of the location pointed to by n. N is used as a 15-bit address pointer. The location counter does not change.

Notice that this control is similar to / with the added capability of changing the currently open memory location.

For example:

```
5011/  7777 55%  102055  [CR]
```

The contents of 5011 are changed to contain the quantity 55; then location 55 is opened and its contents are printed.

n\% Same as n% except that n is interpreted as an instruction, and only the 11-bit address field is used as a pointer to the location to be opened and printed.

For example:

```
4011/ ADB 215 ADB 312\% 4445 [CR]
312/ 4445 [CR]
4001/ ADB 312
```

The contents of 4001 are changed to point to location 312. Location 312 is then opened and its contents printed. It is then opened again for comparison. Notice that we reprint location 4001 to verify the change.

Memory/Location Counter Changes

The following controls allow us to store a new address in the currently opened location and then open, print and set the location counter to the address into which we have just stored.

nCTRL-I Stores n in the currently open register and then opens and prints the contents of the location pointed to by n. Remember that the quantity is interpreted as a 15-bit address. The location counter is set to this address.

For example:

```
36012/  ISZ 36772,I  /   ISZ 36773 =36773 36770 [CNTL-I]
36770/  STB 37770,I  =177770 [CR]
36772/  ISZ 36770  =36770
```

Location 36012 contains an indirect reference to location 36772, which contains 36773. Before 36770 CTRL-I is typed location 36772 is the open location. Typing 36770 CTRL-I changes the contents of 36772 to the value 36770 and then opens and prints the contents of location 36770, with the location counter set to this address.

n\CTRL-I Same as nCTRL-I except that n is interpreted as an instruction.

For example:

```
36012/   JMP 36077   JMP 36200\[CTRL-I]
36200/   JMP 36477[CR]
36012/   JMP 36200
```

Location 36012 originally contains a JMP 36077. This is changed to a JMP 36200, and location 36200 is opened, printed the location counter is set to location 36200.

This control is excellent for making in-core patches. For example, suppose it is necessary to insert instructions between locations 3737 and 3740:

```
3737/  ADA  200
3740/  SSA
```

The inserted code must be stored at locations remote from the in-line code, therefore, we must jump to the added instructions from location 3737 and return to location 3740.

Assuming that memory is available at location 3745, we can use DBUGR as follows:

```
3737/  ADA  200  JSB  3745  \[CTRL-I]
3745/  0  [LF]
3746/  0  ADA 200   [LF]
3747/  Inserted code
          .
          .
          .
          .
37xx/  0  JMP 3745,I
```

Note that the ADA 200 was moved to the beginning of the inserted code to make room for the JSB instruction.

Special Register Modification and Examination

To examine user or system maps, modify or examine O-, E-, X-, Y-Registers, or examine the DMS status as of the last breakpoint, special modes are required.

Special Register Display

\M [CR] will cause the following two lines to be displayed:

```
AREG BREG XREG  YREG EOREG MASK   (CBVAL-CBADDR,I) CBMASK = CBTEST
11   237  11376 5775 2     177777 7      22042     177777   SZA
```

AREG	A-Register
BREG	B-Register
XREG	X-Register
YREG	Y-Register
EOREG	E-, O-Registers in bits 1 and 0, respectively.
MASK	Search Mask
CBVAL	Conditional Breakpoint Value
CBADDR	Conditional Breakpoint Address
CBMASK	Conditional Breakpoint Mask
CBTEST	Conditional Breakpoint Test Instruction

The special registers are accessible by the symbol names given above, the same way user defined symbols may be accessed. The EOREG holds the extended bit status in bit 1, and the overflow bit status in bit 0. For example, EOREG = 3 means extend and overflow are set. EOREG = 1 means extend register clear and overflow register set.

The last four lines above set conditional breakpoints, described in Chapter 6.

Two other symbols available to the user are:

WRTLU   The EXEC control word of the device for DBUGR output (refer to the RTE-6/VM Programmer's Reference Manual regarding EXEC calls). This can be modified so that output will go to an LU or spool device other than the user's terminal.

BRFLG   0 means check for break in program loops being debugged, and allow user to regain interactive control.

1 means no check will be made for break (speeds up loop processing).

MEM Status Special Mode

The following special mode displays the MEM status.

? displays the MEM status as of the last breakpoint in the following format:

```
MS = X15 X14 X13 X12 X10 YYYY
```

where X15, X14, X13, X12, X11 and X10 = MEM status register bits 15, 14, 13, 12, 11, and 10, respectively. YYYY is the four digit octal number representing the base page fence.

Map Examination Special Mode

The following special mode allows examination of the system and user maps and cross load.

\J puts DBUGR into this special mode and responds with a CR LF and three spaces.

UM Displays the user map.

SM Displays the system map.

XL Sets up this special mode to cross load from an address in the alternate map.

PA Displays the port A maps.

PB Displays the port B maps.

A Aborts the special mode with no change.

UM:

0 = MR0	20 = MR20
1 = MR1	21 = MR21
2 = MR2	22 = MR22
3 = MR3	23 = MR23
4 = MR4	24 = MR24
5 = MR5	25 = MR25
6 = MR6	26 = MR26
7 = MR7	27 = MR27
10 = MR10	30 = MR30
11 = MR11	31 = MR31
12 = MR12	32 = MR32
13 = MR13	33 = MR33
14 = MR14	34 = MR34
15 = MR15	35 = MR35
16 = MR16	36 = MR36
17 = MR17	37 = MR37

The system map registers (MR) routine operates the same as the user map registers routine except "UM" is replaced by "SM".

The cross load routine begins by outputting a CR, LF and six spaces with XL followed by three more spaces. The operator then enters an address and a slash to display the contents of that address in the alternate map. DBUGR will return to allow additional cross loads.

For example:

```
XL

      XL   ADDRESS/  (contents from alternate map)
      XL
```

An LF will also increment the address counter as in the case of examining memory locations in the user map.

Temporarily Change to the Print Mode

There are several controls that we can use in place of n/ and n\/ (refer to paragraph 3-1). As with \!, \=, \' and \<- they temporarily change the print mode until we execute a carriage return, thereby returning to master mode. However, unlike \!, \=, \' and \<-, they open and print the contents of a location.

n$	Same as n/ except sets temporary print mode to symbolic instruction.
n#	Same as n/ except sets temporary print mode to numeric constant.
n@	Same as n/ except sets temporary print mode to address pointer.
n)	Same as n/ except sets temporary print mode to ASCII.
n\$	Same as n\/ except sets temporary print mode to symbolic instruction.
n\#	Same as n\/ except sets temporary print mode to numeric constant.
n\@	Same as n\/ except sets temporary print mode to address pointer.

These controls can be used without a preceding address expression (n), in which case they can be used in place of / and \/. However, the mode change will be momentary only. Below are given two examples.

Example #1:

```
\C                                                  Begin in constant mode
2537/   421    [CR]
2540$   LDA    2534,I   / LDA 62572 / 234 [LF]      Change to symbolic
                                                    temporary mode
2541/   ADA    2740     [LF]
2542/   SSA             [LF]
2543/   JMP    2657     [LF]
2544/   CLA             [LF]
2545/   STA    2663     [LF]
2546/   LDB    2661     [LF]
2547/   STB    2662     [CR]                        Return to constant mode
[LF]
2550/          125503   [LF]
2551/          46664    [LF]
2552/          6020     [CR]
4000$          SZA      [LF]                        Change to symbolic
                                                    temporary mode
4001/   JMP    4016     [LF]
4002/   LDA    1717     [LF]
4003/   STA    5235   / CPA   72525  / JSB 34 [LF]
4004/   STA    5236     [CR]                        Return to constant mode
[LF]
4005/   53266           [LF]
4006/   73237           [LF]
4007/   17575           [LF]
```

Example #2:

```
\S                                                  Begin in symbolic mode
4012/   LDB    1717     [LF]
4013/   ADB    5273     [LF]
4014/   CLA             [LF]
4015/   STA    1,I      [LF]
4016/   LDA    4103     [LF]
5000#   2003 /  72053 [LF]                          Change to constant
                                                    temporary mode
5001/   126775          [LF]
5002/   73240           [LF]
5003/   12306           [LF]
5004/   73242           [LF]
5005/   2400            [CR]                        Return to master mode
[LF]
5006/   STA    1,I      [LF]
5007/   LDA    5240     [LF]
```

Chapter 4
Load, Punch, and Verify Paper Tape

Program Load

Y means yank, for loading absolute relocatable records:

\Y Loads absolute relocatable records from LU 5. Enable LU 5 before typing \Y. Loading will terminate at end of file, or upon any attempt to load beyond the upper address limit of the program. DBUGR will report an error for any attempt to load over itself.

Dumping Tables and Patches

D means dump. Memory locations can be changed and dumped on LU 4, one by one, or blocks of memory can be dumped.

Since the data is dumped in an absolute relocatable format readable by HP absolute program loaders, we can use these controls to dump entire programs, tables, or patches.

n1<n2>\D Dumps locations n1 to n2 inclusive.

n\D Stores the value n into the open register, if any; then dumps the register last opened (with the new contents, if stored).

Let's say we have have discovered a bug and must make the following changes:

Location	Instruction	Change
2050	RBR	RAR
2051	SSB	SSA

Using DBUGR in symbolic instruction mode:

```
2050/  RBR  RAR  \D  [LF]
2051/  SSB  SSA  \D
```

One record is created for each word changed.

Tape Verification

To verify a file, we use the following control:

\V Verifies LU 5 against memory. Remember V means verify. Enable LU 5 prior to typing \V. Mismatches are listed as follows:

Address/ [contents of memory] [contents of tape]

If the word on tape is zero, no mismatch is listed. Verification will finish at end of file or upon any attempt to verify beyond the upper address limit of the program. DBUGR will report mismatches within itself.

Chapter 5
Memory Search and Clear

Memory Search

We can search memory within an address range for words that are either equal or not equal under a logical mask to a value.

Actually, memory is searched for a quantity that is equal or not equal to a value formed by taking the logical product (AND) of the mask and each memory location examined. This allows us to search for only a set of bits within each word.

The Search Mask

The mask is stored at a location referenced by the symbol "MASK". Initially it is set to 177777. Now let us open and print location MASK:

<u>MASK/</u> 177777 We can now change the mask.

Logical Product Reviewed

If we take the logical product between a mask and another word, we end up with a result that saves the original value (either 0 or 1) of all bits in the word masked by 1's and clears or extracts all bits in the word masked by 0's. Suppose we wish to search on the lower eight bits in a word:

$$
\begin{array}{rcl}
\text{Mask} = 000377_8 & = & 0000000011111111_2 \\
\text{Word} = 073123_8 & = & 0111011001010011_2 \\
\hline
\text{Logical Product} = 000123_8 & = & 0000000001010011_2
\end{array}
$$

The result of the operation is to clear out all bits in which we are not interested and to save only the lower eight bits for comparison against some 8-bit value.

Address Range

The following controls establish the range of addresses applied to a search:

n1 Sets the lower limit to n1.

n2 Sets the upper limit to n2.

The limiting addresses are included in the search.

Equality Search

n\W Searches within the address range for all words equal under the mask to n. Remember, W means word.

Example #1: Search within locations 2000 and 3000 inclusive for all halt instructions (1020xx).

```
MASK/   177777   177700   [LF]     Change mask to ignore
                                   bits 0-5

2000<3000>102000\W
2234/     102002
2337/     102002
2361/     102011
2572/     102002
2641/     102002
2710/     102002
2743/     102002
2756/     102002
```

Example #2: Search within locations 36012 and 36041 inclusive for all halt 51 instructions in the program.

```
MASK/   177777
36012<36041>102051\W
36027/  102051
```

Inequality Search

n\N Searches within the address range for all words under the mask not equal to n. Remember, N means not equal to word.

Example: Search memory within locations 2270 and 2315 inclusive. Print words not equal to zero.

```
MASK/    177777   [CR]        Verify mask
2270<2315>0\N
2270/    50262
2271/    26303
2272/    26255
2273/    64124
2274/    6002                  Locations not containing
2275/    26246                 zero are listed.
2276/    34242
2277/    170155
2311/    70155
2312/    160156
2313/    70243
2314/    30374
2315/    170574
```

The listing shows that locations 2300 through 2310 contain zero.

Clear or Set Memory

n\\Z Zero, or set memory within the limits specified to n. Remember, Z means zero.

Example #1: Set memory locations 2300 to 2310 inclusive to 177777 (octal); then print these locations to verify the operation.

```
2300<2310>177777\\Z    [CR]
2270<2310>177777\W
2300/     177777
2301/     177777
2302/     177777
2303/     177777
2304/     177777
2305/     177777
2306/     177777
2307/     177777
2310/     177777
```

Example #2: Zero locations 2300 to 2310 inclusive.

```
2300<2310>0\\Z
```

Effective Address Search

The effective address is the location an instruction must reference to acquire or store data. Many times in HP1000 programming addresses are referenced indirectly:

```
LDA   1772,I
```

The above instruction must further reference location 1772 to obtain an effective address from which to load the A-register. If the contents of 1772 = 02340, the LDA instruction would acquire data from location 02340.

n\E Finds all instructions within the limits specified that effectively address location n. Indirect chains are followed to a depth of 16. Normally the mask is set to all 1's, but if not, n is treated as specifying a range of addresses, and all instructions effectively referencing addresses within that range are printed. Remember, E means effective address.

Example #1: Find all instructions within 2000 and 3000 inclusive that reference location 70567.

```
MASK/    177777      [CR]
2000<3000>70567\E
2050/    165775                2050 references 70567 indirectly
                               through 1775.

1775/    70567                 Print location 1775 to verify
                               operation.
```

Example #2: Find all instructions within 2000 and 3000 inclusive that effectively address any location in the range 4060 to 4067.

```
MASK/    177777    177770        [CR]
2000<3000>4065\E
2500/    JMP       1500,I        All instructions indirectly
2550/    JMP       1503,I        reference locations in the
2600/    ADA       1503,I        range 4060 to 4067.
2700/    JMP       1503,I
\C
1500/    4060      [LF]          Verify by printing the
                                 contents of the pointers.
1501/    4062      [CR]
1503/    4065
```

Note the effect of the mask. By placing a 0 as the lowest octal digit of the mask, no specific address is specified for this digit position, therefore the entire range of addresses from 4060 to 4067 is processed.

Chapter 6
Breakpoint/Trace Debugging

Introduction

Breakpoint trace debugging is simply a matter of forcing the computer to halt at a particular point in its program execution so we can look at what is happening. We can examine operational registers, dump memory and make memory patches. Of course, we must have a means of resuming execution after a breakpoint and the ability to control the number of times we actually break within a programmed loop.

Combining memory examination and change controls, search and print controls, and binary patching with the breakpoint trace capability makes DBUGR the powerful tool that it is.

To aid in the tracing operations of a program, a breakpoint may be set at most instructions. When control reaches that instruction, it is not immediately executed; DBUGR gains control and prints out the following:

```
ADDRESS(INSTRUCTION)    A    B    EO STATUS
```

1. Program location counter (P-Register) (in address mode).

2. The "broken" instruction (in instruction mode).

3. Contents of the A- and B-Registers (starts in constant mode may be changed - refer to Chapter 3).

4. As one word the extend and overflow registers (in constant mode - refer to Chapter 3).

Non-segmented breakpoints are set using the following format:

n\B   Where n is the address where the breakpoint is to be set.

Segment breakpoints exist for segmented programs (type 5 EXEC calls and MLS segments) with DBUGR appended to them by the RTE-6/VM loaders. Breakpoints may be set in four different modes (the brackets [] are separators).

1. ["A]\B Break at entry to ALL segments/paths.

2. ["N]\B Break at entry to NO segments/paths.

3. [xxxxx]\B Break at entry to a specific segment/path (xxxxx).

4. n[xxxxx]\B Break at a defined address (n) within a specified segment/path (xxxxx).

A breakpoint will be set when the specified segment/path is loaded during execution. Thereafter, breakpoints remain in effect until a new segment/path is loaded during execution. At that time breakpoints associated with the newly loaded segment/path will be set. At such time as the previous segment/path is re-executed, the breakpoints associated with that segment/path will be set, and the breakpoints associated with its predecessor will become dormant.

Setting a Breakpoint (MLLDR)

Breakpoints in MLS programs are associated with nodes and not segments. Nodes are associated with paths of the node tree. An address breakpoint is defined using both the logical address and the node's path number. A path switch breakpoint is defined in terms of the node's path number.

The path number of a node is the ordinal node number of its subtree's leftmost leaf node. Nodes are numbered in preorder. The ordinal number of the root node is zero. For example:

```
                      +---+
                      | 0 |
                      +---+
                        v
             -------------------------
             v     v     v     v     v
           +---+ +---+ +---+ +---+ +---+
           | 1 | | 5 | | 6 | | 7 | | 8 |
           +---+ +---+ +---+ +---+ +---+
             v                       v
       -------------              -------
       v     v     v              v     v
     +---+ +---+ +---+          +---+ +----+
     | 2 | | 3 | | 4 |          | 9 | | 10 |
     +---+ +---+ +---+          +---+ +----+
```

Node Ordinal	Path Number
0	2
1	2
2	2
3	3
4	4
5	5
6	6
7	7
8	9
9	9
10	10

Therefore, to set a breakpoint in node 8 at logical address 50123 the user would give the command:

```
50123[9]\B
```

How a Switch Enables New Breakpoints

Assume path 2 is the current path and breakpoints have been defined at 50123[9] and 502037[10] where node 8 has a logical address range of 50000B to 60000B. The first time node 8 is referenced (through path 9) the breakpoint 50123[9] will be enabled and the breakpoint 50237[10] will not be enabled. This is because the breakpoint at 50123 is associated with path 9, the other breakpoint associated with path 10 is not yet switched in, and node 8 lies in path 9 only at this time.

How a Breakpoint Can Persist Through Path Switches

When node 10 is referenced the breakpoint 50237[10] will be enabled in node 8. Moreover, the breakpoint 50123[9] in node 8 will still be enabled and will persist.

When two paths flow through a common node, breakpoints for the common node are added to the breakpoints table as each path is enabled, and stay as long as a path exists with the common node. Only after a path switch occurs (like to path 3) and node 8 is switched out will the breakpoints become disabled. Thus, breakpoints become enabled when their associated path is switched in, and persist until the node they reside in is switched out.

A segment/path entry breakpoint displayed just after segment/path access would look like:

```
PATH      XXXXX  SWITCH      (if MLLDR)
SEGMENT   XXXXX  BREAK       (if LOADR)
ADDRESS(INSTRUCTION)    A    B    X    Y    EO STATUS
```

When a segment entry breakpoint is defined, DBUGR makes no check for the validity of the segment name. Therefore, segment names should not begin with ("A) or ("N).

Conditional Breakpoint

A conditional breakpoint can be set that will only break when a particular memory location is equal (or not equal) to a particular value after being masked. Location CBVAL, CBMASK, CBADDR, and CBTEST are used to set up the conditions required for the breakpoint to occur. The conditions are set up as follows:

CBVAL	Compare Value
CBMASK	Mask Value
CBADDR	Memory Address to be tested (A-Register=0, B-Register=1)
CBTEST	Condition required for break. For equality enter "SZA" or 2002; for inequality enter "SZA, RSS" or 2003. Note that the comparison is logical and not arithmetical.

The conditional breakpoint may be invoked only upon an existing breakpoint. Moreover, the program must be proceeding from that breakpoint. The conditional test will be applied only at that particular breakpoint.

The conditional breakpoint is invoked by the double escape P command (\\P). Each time the breakpoint is encountered, the contents of the address specified by CBADDR will be XOR'ed with the contents of CBVAL. The result will be AND'ed with CBMASK and this final result will be tested with the instruction in CBTEST (SZA or SZA,RSS). The equation for this test appears in the "\M" display:

```
(CBVAL-CBADDR,I)^CBMASK = CBTEST
```

If the test instruction "skips", the conditional breakpoint will "break". If not, DBUGR will proceed. The conditional breakpoint may be counted with the n\\P command. In this case the conditions will be checked before the breakpoint is counted. A count is made only if a break would have been made. Therefore, n\\P will count n breaks before printing a break message.

In order to delete a breakpoint from the breakpoint table, give the \B command. Then the breakpoint table will be listed:

```
0           M+347      breakpoint in main memory
1 SEG1      77777,I    segment entry breakpoint
2 SEG2      BETA       breakpoint in SEG1
3 SEG3      PHI+5      breakpoint in SEG2
ENTER INDEX OF BP TO DELETE, A to END 1 [CR]
ENTER INDEX OF BP TO DELETE, A to END A
```

Breakpoint 1, the segment entry breakpoint for SEG1, was deleted.

A faster command for deleting breakpoints is \\B which deletes all breakpoints at once.

If an attempt is made to enter more breakpoints than the capacity of the breakpoint table, an error message will be displayed.

```
NO MORE ROOM FOR BREAKPOINTS
```

The user should either delete some breakpoints or create a larger breakpoint table module to be loaded with the DBUGR in the future.

Restrictions

We are, however, restricted in the instructions at which a breakpoint can be set. This is because DBUGR gains control at the breakpoint by replacing the programmed instruction with a jump to DBUGR itself. After the break has been accomplished, the instruction is either executed from its temporary location within DBUGR or execution resumes at another address specified by the user via \G.

DO NOT set breaks at the following:

1. Instruction used as data.
2. Instruction that is used as an address pointer in an indirect chain of an instruction.
3. Instruction that is program modified (e.g., a configured I/O instruction).
4. EIG or DMS instructions listed in Figure 6-1.

CAUTION

> In DBUGR, an attempt to JSB to a point below the MP fence (except in an EXEC call) as the result of a trace or proceed command causes DBUGR to reject the command and to print the break message for the violating instruction followed by "MP?". You can get around this problem if the offending instruction is no longer a breakpoint. The solution then is to move the breakpoint to a point after the system call and then proceed.

Not Allowed

DJP	DJS	SJS	SJU	UJP
UJS	XCA	XCB	XSA	XSB

Figure 6-1. Untraceable Instructions

Controls

Breakpoint controls in DBUGR are:

n\B	Set a breakpoint at n. Remember, B means breakpoint.
\B	List breakpoint table and enter remove breakpoint mode.
\\B	Remove all breakpoints.
["A]\B	Break at entry to ALL segments or path switches.
["N]\B	Break at entry of NO segments or paths (remove breakpoint).
[SEG1]\B	Break at entry to a segment named SEG1 (LOADR).
[VALUE]\B	Break on switch to path <value> (VALUE is decimal) (MLLDR).
n[SEG1]\B	Break at n within a segment named SEG1 (LOADR).
n[VALUE]\B	Break at n octal path # <VALUE> (MLLDR).
\P	Proceed with program execution after a break. Remember, P means proceed.
\\P	Proceed with conditional breakpoint invoked.
n\P	Proceed; do not trap until n breaks from now. All breakpoints encountered contribute to the count.
n\\P	Proceed with conditional breakpoint invoked. Do not trap until n breaks from now. Breakpoints encountered other than the particular conditional breakpoint may contribute towards this count.
\O	Change break point and trace register print mode to the current master print mode.
n\G	Go to location n; begin execution with flags and accumulators as they were at break. Remember, G means go.

n\X	Execute the instruction n, then return control to DBUGR. If the instruction is a jump, DBUGR loses control. DBUGR prints a carriage return/line-feed before and after executing the instruction. If the instruction performs a skip, DBUGR prints an additional carriage return/line-feed. Remember, X means execute.
\T	Trace one line of code. DBUGR simulates (executed by software instead of hardware) the instruction printed in the last break message and then prints a new break message with the new location, instruction and registers. Two-word instructions also print the address used by the instruction. Tracing data may be unpredictable.
n\T	Trace n instructions. Causes n break messages to be printed.
\\T	Trace through a subroutine call. Unlike a \T trace of a JSB, a one-shot breakpoint is placed at "..+1". Control passes to the subroutine and is regained upon return with a break. The one-time breakpoint is thus removed. This command should not be used when the JSB is followed by an argument list. Also, it should not be used when the called subroutine may return to somewhere other than "..+1".

Example #1: Break at location 77710.

```
77710\B                                 Set breakpoint at 77710.
77700\G                                 Begin execution at 77700.
77710 (CLA)   173775    13   14 0       DBUGR prints this.
EOREG/        0                         Examine EOREG for flags.
```

Example #2: Breakpoint within a loop.

```
LOOP+15\B                               Set breakpoint at LOOP+15.
LOOP\G                                  Begin execution at LOOP.
LOOP+15 (CLE) 4324   17   0 41    3     DBUGR prints this.
EOREG/          3                       Examine EOREG for flags.
10\P                                    Proceed
LOOP +15 (CLE) 57211 5   2 24    3      DBUGR prints this
\P                                      Continue execution.
```

Example #3:

```
RU,MAIN                                  Execute program loaded with
                                         DBUGR
   START DBUGR
16002<M:        23456<S:      [CR]       Set start address of MAIN and
                                         SEG
[SEG1]\B                                 Set Entry Breakpoint in SEG1.
\P
SEGMENT SEG1 BREAK
S   (0)   17542 5608 17702   22   2
S+5[SEG2]\B                              Set Breakpoint in SEG2
\P
SEGMENT SEG2 BREAK
S+5 (CLA) 17542 5606 0 45 22
M+50\B                                   Set Breakpoint in MAIN
[SEG4]\B                                 Set entry Breakpoint in SEG 4
\P
M+50(LDA M+700) 0 2234 54 72 1           Break in MAIN
\P

SEGMENT SEG4 BREAK
S   (0)   17445 5562 7422 3322 1
                                         Break at segment load.
\P
S+10 (JSB 112,I)   24 0 177777 55 2
["N]\B                                   Clear segment Breakpoint except
                                         for specified segments.
\P
END DBUGR
```

Example #4:

```
RU,PROG                                       Execute program loaded with
                                              DBUGR
START DBUGR

34221\B                                       Set breakpoint
\P                                            Proceed to breakpoint
34221(LDA 1) 43 243 0 77 1

CBVAL/   0      130[LF]                       Set compare value
CBMASK/  177777 377[LF]                       Set mask to lower byte
CBADDR/   0       1 [LF]                      Test address (B-Register)
CBTEST/   SZA    [CR]                         Test for equality

\\P                                           Proceed with conditional break
                                              invoked

34221 (LDA 1) 32562                           23530 2372 0 0

                                              The lower byte  of  B-Register
                                              is equal to test value.

1/23530 23400 [CR]                            Change lower byte of B-Register
                                              to 0.

\\P                                           Proceed with conditional break
                                              invoked.
34221 (LDA 1) 177777  730 2372 0 0

\P                                            Proceed without conditions.
34221 (LDA 1)   44     25 3372 0 0

\P
END DBUGR
```

The ten breakpoints available in DBUGR reside in a relocatable module named %SGBPT (for LOADR) or %MLBPT (for MLLDR). If the user desires to change the number of available breakpoints, the user may write his own SGBPT/MLBPT module and load the new code in place of the system library routine SGBPT/MLBPT. This can be done by using the loader LI,%SGBPT or LI,%MLBPT command to search the user's %SGBPT or %MLBPT file before the system library is searched.

The routine for %SGBPT looks like:

```
ASMB,R,Q
       NAM SGBPT,7
       ENT SGBPT,SGBPE
SGBPT  DEF *+1            start of table points
       REP 10             determines number of breakpoints (10)
       OCT 0,0,0,0,0
SGBPE  DEF *              end of table pointer
       END
```

The routine for %MLBPT looks like:

```
ASMB,R,Q
       NAM MLBPT,7
       ENT MLBPT,MLBPE
MLBPT  DEF *+1            start of table points
       REP 10             determines number of breakpoints (10)
       OCT 0,0,0,0,0
MLBPE  DEF *              end of table pointer
       END
```

Magic Symbols

DBUGR has two magic symbols, dot (.) and double dot (..). A magic symbol is one of DBUGR's working registers (variables) that is also in its symbol table. We already know about "." which is DBUGR's location counter. Normally "." is set to some value with one of the many commands that open a register, but it also may be set this way:

```
201 < .:
.= 201    [LF]    verify "." was set
202/  CLA
```

".." is defined, whenever DBUGR is entered or processing a break point message, to be the next instruction's address. Thus if we have just broken:

```
3011   (CLA)    10    4010    12   77   2    ..=   3011
```

".." is set each trace and/or break. This provides a convenient way of opening the broken location but is even more powerful when we use it to move the trace location. Thus:

```
3011   (CLA)    10    4010    12   77   2 [CR]

..-1/  STA   3040   JMP 3022 [CR] patch previous instruction
```

Appendix A
More About Operators

Now that we have used most of the controls in DBUGR let's take a closer look at the use of operators (refer to Chapter 1.) within address expressions.

Plus, Blank and Minus

The minus sign (-) performs subtraction. The operators plus (+) or blank are used to perform addition. Suppose we wish to change the jump at location 2513:

2513/	JMP 2522	JMP 2522+3	Type jump address as a relative address and verify by reexamining 2513.
./	JMP 2525		

Or, let's print the contents of SYM+5, a symbol we have defined as being equal to 2500:

SYM+5/	INA	Type the symbolic address and verify by printing the contents of the same address expressed in in octal.
2505/	INA	

Inclusive OR

Now we use the operator comma (,) to inclusive OR a CLA with an INA, thereby creating the combined register operation CLA, INA:

62572/	CLA	CLA,INA	[CR]	Change register 62572.
.	2404			Verify new contents in octal.

or in octal:

```
\C
62572/    2400    002400,002004
```

The Mark \Q

Note that in the previous example we had to retype the CLA to use it in the inclusive OR expression. This is not really a lot of trouble, but we do have a mark that, when in an expression, implies the last quantity typed. Thus,

```
62572/   CLA   CLA,INA          Can also be accomplished by the
                                mark, \Q:
62572/   CLA   \Q,INA
./       CLA,INA   =2404
```

The mark \Q implies the last quantity typed, in this instance CLA. Remember that Q means last quantity typed.

For example:

```
2050/   2004   \Q+\Q  = 4010   Q+100000 = 104010
```

Using DBUGR to do Simple Arithmetic

We can use DBUGR to evaluate simple expressions, and to convert decimal or octal numbers to other radices. The following sections illustrate this capability.

Octal Addition and Subtraction

```
[CR]
234+766=1222
5444-45=5377
4564+567-34+125=5444
```

Other Conversions

2.\R	Change to binary output
23=1001	Convert octal to binary
16\ R	Change to hexadecimal output
14=C	Convert octal to hexadecimal
78.=4E	Convert decimal to hexadecimal

Decimal Addition and Subtraction

```
10.\R
45.+56.=101.
578.+9788.=10366.
400.-45.-26.-78.=251.
```

Octal to Decimal Conversion

```
10.\R
245=165.
256+77+654-147=562.
```

Decimal to Octal Conversion

```
8.\R
89.=131
7859.=17263
78.+59.=211
998.-997.=1
```

Appendix B
Error Messages

DBUGR will recognize various types of errors. The messages and their meanings are as follows:

X	You pressed the RUB OUT key to delete a typing mistake. DBUGR will ignore any prior partial expression.
?	You used an unassigned control (including backspace). Any prior expression is ignored. Input Error in special mode.
U	The symbol last used was undefined and a definition was required. The entire preceding expression is ignored.
P?	Page error: You caused a memory reference instruction to reference an address not in the current page or the base page. The expression is ignored. DBUGR's conception of the "current page" can be changed by examining any location in the desired page.
CHK	A checksum error has occurred while reading from LU 5.
MP?	DBUGR detected a possibly legal instruction that it cannot trace (or proceed with the break point at) without violating memory protect. Move the break point and proceed.
IN?	An instruction that is legal in the 21XX base set but not executable by DBUGR was detected and DBUGR cannot trace (or proceed with the breakpoint at). Move the breakpoint and proceed. User attempted to set a breakpoint on an instruction DBUGR cannot proceed from. Execution of an instruction using the (instruction)EX feature of DBUGR was attempted using a two or more word instruction (not supported - only one word instructions can be executed using this feature).
TP?	An attempt to trace, set breakpoint, or paper tape load into DBUGR. Loading, tracing, or setting of breakpoint is terminated.
O?	Symbol table overflow.
DM?	An attempt to access memory that is beyond the program.

Appendix C
DBUGR at a Glance

Table C-1. Quick Reference To Frequently Used Commands

COMMAND	EXPLANATION
n/	print contents of location n
\L	list 16 locations
n\L	list n locations
n\R	set Radix to n
\S	Symbolic mode
\C	Constant mode
\H	hollerith mode
\A	address mode
n<sym:	define sym as n
n\X	execute n
n\G	Go, starting at location n.
\P	proceed
\\P	proceed with conditional breakpoint
\T	trace an instruction
n\P	proceed for n breaks
n\\P	proceed with cond. breakpoint for n breaks
n\T	trace n instructions
n\B	set breakpoint at n
[x]\B	set entry breakpoint for segment/path x
n[x]\B	set breakpoint in segment/path x at n
\B	list breakpoint table and enter remove breakpoint mode
\\B	clear all breakpoints
n1<n2>n3\W	search n1 to n2 for n3 under mask
n1<n2>n3\N	search n1 to n2 for not equal to n3 under mask
\M	display special register
\J	enter map display mode

Mode Control

DBUGR has several basic printing modes:

* As symbolic instructions. This is the mode DBUGR is in when loaded. Controls are:

\S	Set the master printing mode to symbolic instruction.
!	Print the last quantity typed as an instruction.
\!	Set temporary printing mode to instruction, and print the last quantity typed as an instruction.

* As address pointer.

\A	Set the master printing mode to address. If only initial symbols are defined, this is equivalent to constant.
<-	Print the last quantity typed as an address pointer.
\<-	Set temporary printing mode to address, and print last quantity typed as an address.

* As constants, in a specified radix.

\C	Set the master printing mode to constants, in the current radix.
=	Print the last quantity typed as a constant.
\=	Set the temporary printing mode to constant, and print the last quantity typed as a constant.
n\R	Set the output radix to n.

* As ASCII characters in halfwords.

\H Set the master printing mode to ASCII characters in half-words.

' Print the last quantity typed as two ASCII characters. Then print ".

\' Set the temporary printing mode to ASCII, and print the last quantity typed as ASCII.

s" The symbol s, of one or two characters right-adjusted, is taken as a term on input.

* To print a quantity in the current master print mode:

; Print last quantity typed in current mode.

* To change the breakpoint register print mode to current master print mode:

\O

* To operate in character or block mode (multipoint terminals). Refer to Appendix D.

\\U Switch from character to block mode or vice versa.

* To change a print mode temporarily:

$	Same as bar (/), but set temporary print mode to symbolic instruction. Temporary mode is in effect over a series of examinations, until carriage return is typed by you, then the master mode becomes in effect again.
\$	Same as escape bar, but set temporary print mode to symbolic instruction.
@	Same as bar, but set temporary print mode to address pointer.
\@	Same as escape bar, but set temporary print mode to address pointer.
#	Same as bar, but set temporary print mode to constant.
\#	Same as escape bar, but set temporary print mode to constant.
)	Same as bar, but set temporary print mode to ASCII.
\)	Same as escape bar, but set temporary print mode to ASCII.

Symbol Manipulation

s:	Define the symbol s as having value specified by the location counter.
s&	Define symbol s as having value equal to the address of the last quantity typed, if an instruction.
\K	Kill all symbol definitions other than the initial symbol table.

Location Examination

n/	Print the contents of location n, in the current master print mode, and open the location for possible modification. The location counter is set to n.
/	Open and print the contents of the location pointed to by the last quantity typed, taken as a direct 15-bit address. The location counter is not changed.
\/	Open and print the contents of the location pointed to by the last quantity typed, taken as a memory reference address instruction. The location counter is not changed.
\L	Open and print the contents of the next 16 sequential locations starting with the current location. The location counter is advanced by 16.
n\L	Same as \L, except list n lines.
[CR]	Close any open location. No change is made.
n[CR]	Store the quantity n in the open location, if any, and close the location.
[LF]	Open and print the contents of the next sequential location as determined by the location counter. The location counter is advanced by one.
n[LF]	Store the quantity n in the open location, if any; then open and print the contents of the next sequential location. The location counter is advanced by one.
^	Open and print the contents of the previous sequential register. The location counter is decremented by one.
n^	Store the quantity n in the open location, if any; then open and print the contents of the previous sequential location. The location counter is decremented by one.
CTRL-I (TAB)	Open, set the location counter to, and print the contents of the location pointed to by the quantity typed, taken as an address pointer.
nCTRL-I (nTAB)	Store the quantity n in the open location, if any. Then open, set the loction counter to, and print the contents of the location pointed to by n, taken as an address.

\TAB	Open, set the location counter to, and print the contents of the location pointed to by the last quantity typed, taken as an instruction.
n\TAB	Store the quantity n in the open location, if any. Then open, set the location counter to, and print the contents of the location pointed by n, taken as an instruction.
n%	Store the quantity n in the open location, if any. Then open and print the contents of the location pointed to by n, taken as an address. The location counter is not changed.
n\%	Store the quantity n in the open location, if any. Then open and print the contents of the location pointed to by n, taken as an instruction. The location counter is not changed.

Program Load and Verify

\Y	Load absolute record from LU 5.
\V	Verify cassette tape against memory (LU 5).

Dumping

n\D	Store n into the open location, if any. Then dump the last register (with the new contents n, if stored) to LU 4.
n1<n2>\D	Dump locations n1 to n2, inclusive.

Memory Search and Clear

n<	Set the lower limit for search or clear to n.
n>	Set the upper limit for search or clear to n.
n1<n2>n3\W	Search between the limits n1 and n2 for all words equal under mask to n3.
n1<n2>n3\N	Search between the limits n1 and n2 for all words not equal under mask to n3.
n1<n2>n3\E	Effective address search: find all instructions between the limits n1 and n2 which, under mask, effectively address location n3.
n1<n2>n3\\Z	Zero, or clear core between the limits n1 and n2, to n3. If n3 is omitted, it is taken as zero.
MASK\	Examine/modify search mask.

Breakpoints and Program Control

n\B	Set a breakpoint at n. If n is in segment/path space, use last segment/path loaded as the associated segment name/path. Error if no segment loaded yet.
\B	List breakpoint table and enter remove breakpoint mode.
\\B	Remove all breakpoints
n[NAME]\B	Set a breakpoint in segment NAME at location n (LOADR).
n[VALUE]\B	Set a breakpoint in path <VALUE> at location n (MLLDR).
[NAME]\B	Break at entry to Segment NAME (LOADR).
[VALUE]\B	Break at entry to path <value> (MLLDR).
["A]\B	Break at entry to ALL Segments/Paths.

["N]\B	Break at entry to NO Segments/paths except for those specified.
\P	Proceed with program execution after a break trap.
\\P	Proceed with conditional breakpoint invoked.
n\P	Proceed; do not trap until n breakpoints from now.
n\\P	Proceed; do not trap until n breakpoints, including conditional breakpoints.
n\G	Go to location n; begin execution with flags and accumulators as saved.
n\X	Execute the instruction n, then return control to DBUGR.
\T	Trace one instruction.
n\T	Trace n instructions.
\\T	Trace an entire subroutine call with no argument list or alternate returns.

Trace/Breakpoint simulation:

DBUGR simulates instructions when it:

a) Proceeds from the current breakpoint location

b) Traces

c) Executes an instruction

DBUGR will correctly simulate all instructions including EXEC calls in its symbol table when tracing, with the exceptions noted in Figure 6-1. A breakpoint may not be set on any of these instructions.

A method to get around instruction exceptions is to set up a subroutine containing the desired instruction(s) and execute a JSB <subroutine>\X. DBUGR will give up control to the subroutine and execute it, regaining control on the return.

Special Registers

\M	Display contents of the special registers.
AREG/	Examine & Modify A-Register
BREG/	Examine & Modify B-Register
XREG/	Examine & Modify X-Register
YREG/	Examine & Modify Y-Register
EOREG/	Examine & Modify EO-Register
MASK/	Examine & Modify Search Mask
CBVAL/	Examine & Modify conditional breakpoint value
CBMASK/	Examine & Modify conditional breakpoint mask
CBADDR/	Examine & Modify conditional breakpoint address
CBTEST/	Examine & Modify conditional breakpoint test
WRTLU/	EXEC control word for DBUGR output device
BRFLG/	Break Flag; 0= check for break, 1= no check

Map Registers

\J:	SM	Examine system maps.
	UM	Examine user maps.
	PA	Examine port A maps.
	PB	Examine port B maps.
	XL	Cross load A- or B-Registers.
\?	Display MEM status register.	

Appendix D
Block Mode Operation of DBUGR

DBUGR can be operated in block mode. Multipoint (DVR07) terminals run in block mode only.

Escape, return and line feed cannot be used in block mode.

The following are the differences between character and block mode.

CHAR MODE	BLOCK MODE
<escape>	\
<cr>	]
<lf>	<enter for multipoint> <return for non-multipoint>

In order to invoke block mode operation on a non-multipoint terminal enter the following command:

```
\\U
```

When in block mode this command will set DBUGR back to character mode for non-multipoint terminals.

Since DBUGR does not receive any character until the enter or return is entered, a series of commands may be entered on one line.

For example:

```
200/201/202/<enter>
   JSB 4,I    203    245
200/<enter>
   JSB 4,I    <enter>
201/ 203      <enter>
202/ 245      ]<enter>
```

Appendix E
HP Character Set

Effect of Control key *

					000-037B		040-077B		100-137B		140-177B	
$b_7\ b_6\ b_5$					0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
BITS				COLUMN →	0	1	2	3	4	5	6	7
b_4	b_3	b_2	b_1	ROW ↓								
0	0	0	0	0	NUL	DLE	SP	0	@	P		p
0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	$	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	10	LF	SUB	*	:	J	Z	j	z
1	0	1	1	11	VT	ESC	+	;	K	[	k	{
1	1	0	0	12	FF	FS	,	<	L	\	l	¦
1	1	0	1	13	CR	GS	-	=	M	]	m	}
1	1	1	0	14	SO	RS	.	>	N	∧	n	~
1	1	1	1	15	SI	US	/	?	O	_	o	DEL

32 CONTROL CODES

Upshifted Lower Case

64 CHARACTER SET

96 CHARACTER SET

128 CHARACTER SET

EXAMPLE: The representation for the character "K" (column 4, row 11) is.

	b_7	b_6	b_5	b_4	b_3	b_2	b_1
BINARY	1	0	0	1	0	1	1
OCTAL	1		1			3	

* Depressing the Control key while typing an upper case letter produces the corresponding control code on most terminals. For example, Control-H is a backspace.

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HEWLETT-PACKARD CHARACTER SET FOR COMPUTER SYSTEMS

This table shows HP's implementation of ANS X3.4-1968 (USASCII) and ANS X3.32-1973. Some devices may substitute alternate characters from those shown in this chart (for example, Line Drawing Set or Scandanavian font). Consult the manual for your device.

The left and right byte columns show the octal patterns in a 16 bit word when the character occupies bits 8 to 14 (left byte) or 0 to 6 (right byte) and the rest of the bits are zero. To find the pattern of two characters in the same word, add the two values. For example, "AB" produces the octal pattern 040502. (The parity bits are zero in this chart.)

The octal values 0 through 37 and 177 are control codes. The octal values 40 through 176 are character codes.

Decimal Value	Octal Values		Mnemonic	Graphic[1]	Meaning
	Left Byte	Right Byte			
0	000000	000000	NUL	NU	Null
1	000400	000001	SOH	SH	Start of Heading
2	001000	000002	STX	SX	Start of Text
3	001400	000003	EXT	EX	End of Text
4	002000	000004	EOT	ET	End of Transmission
5	002400	000005	ENQ	EQ	Enquiry
6	003000	000006	ACK	AK	Acknowledge
7	003400	000007	BEL		Bell, Attention Signal
8	004000	000010	BS	BS	Backspace
9	004400	000011	HT	HT	Horizontal Tabulation
10	005000	000012	LF	LF	Line Feed
11	005400	000013	VT	VT	Vertical Tabulation
12	006000	000014	FF	FF	Form Feed
13	006400	000015	CR	CR	Carriage Return
14	007000	000016	SO	SO	Shift Out } Alternate Character Set
15	007400	000017	SI	SI	Shift In } Alternate Character Set
16	010000	000020	DLE	DL	Data Link Escape
17	010400	000021	DC1	D1	Device Control 1 (X-ON)
18	011000	000022	DC2	D2	Device Control 2 (TAPE)
19	011400	000023	DC3	D3	Device Control 3 (X-OFF)
20	012000	000024	DC4	D4	Device Control 4 (TAPE)
21	012400	000025	NAK	NK	Negative Acknowledge
22	013000	000026	SYN	SY	Synchronous Idle
23	013400	000027	ETB	EB	End of Transmission Block
24	014000	000030	CAN	CN	Cancel
25	014400	000031	EM	EM	End of Medium
26	015000	000032	SUB	SB	Substitute
27	015400	000033	ESC	EC	Escape[2]
28	016000	000034	FS	FS	File Separator
29	016400	000035	GS	GS	Group Separator
30	017000	000036	RS	RS	Record Separator
31	017400	000037	US	US	Unit Separator
127	077400	000177	DEL	▒	Delete, Rubout[3]

Decimal Value	Octal Values		Character	Meaning
	Left Byte	Right Byte		
32	020000	000040		Space, Blank
33	020400	000041	!	Exclamation Point
34	021000	000042	"	Quotation Mark
35	021400	000043	#	Number Sign, Pound Sign
36	022000	000044	$	Dollar Sign
37	022400	000045	%	Percent
38	023000	000046	&	Ampersand, And Sign
39	023400	000047	'	Apostrophe, Acute Accent
40	024000	000050	(	Left (opening) Parenthesis
41	024400	000051	)	Right (closing) Parenthesis
42	025000	000052	*	Asterisk, Star
43	025400	000053	+	Plus
44	026000	000054	,	Comma, Cedilla
45	026400	000055	-	Hyphen, Minus, Dash
46	027000	000056	.	Period, Decimal Point
47	027400	000057	/	Slash, Slant
48	030000	000060	0	Digits, Numbers
49	030400	000061	1	Digits, Numbers
50	031000	000062	2	Digits, Numbers
51	031400	000063	3	Digits, Numbers
52	032000	000064	4	Digits, Numbers
53	032400	000065	5	Digits, Numbers
54	033000	000066	6	Digits, Numbers
55	033400	000067	7	Digits, Numbers
56	034000	000070	8	Digits, Numbers
57	034400	000071	9	Digits, Numbers
58	035000	000072	:	Colon
59	035400	000073	;	Semicolon
60	036000	000074	<	Less Than
61	036400	000075	=	Equals
62	037000	000076	>	Greater Than
63	037400	000077	?	Question Mark

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Decimal Value	Octal Values		Character	Meaning
	Left Byte	Right Byte		
64	040000	000100	@	Commercial At
65	040400	000101	A	
66	041000	000102	B	
67	041400	000103	C	
68	042000	000104	D	
69	042400	000105	E	
70	043000	000106	F	
71	043400	000107	G	
72	044000	000110	H	
73	044400	000111	I	
74	045000	000112	J	
75	045400	000113	K	
76	046000	000114	L	
77	046400	000115	M	
78	047000	000116	N	Upper Case Alphabet, Capital Letters
79	047400	000117	O	
80	050000	000120	P	
81	050400	000121	Q	
82	051000	000122	R	
83	051400	000123	S	
84	052000	000124	T	
85	052400	000125	U	
86	053000	000126	V	
87	053400	000127	W	
88	054000	000130	X	
89	054400	000131	Y	
90	055000	000132	Z	
91	055400	000133	[	Left (opening) Bracket
92	056000	000134	\	Backslash, Reverse Slant
93	056400	000135	]	Right (closing) Bracket
94	057000	000136	∧ ↑	Caret, Circumflex; Up Arrow[4]
95	057400	000137	_ ←	Underline; Back Arrow[4]

Decimal Value	Octal Values		Character	Meaning
	Left Byte	Right Byte		
96	060000	000140	`	Grave Accent[5]
97	060400	000141	a	
98	061000	000142	b	
99	061400	000143	c	
100	062000	000144	d	
101	062400	000145	e	
102	063000	000146	f	
103	063400	000147	g	
104	064000	000150	h	
105	064400	000151	i	
106	065000	000152	j	
107	065400	000153	k	
108	066000	000154	l	
109	066400	000155	m	
110	067000	000156	n	Lower Case Letters[5]
111	067400	000157	o	
112	070000	000160	p	
113	070400	000161	q	
114	071000	000162	r	
115	071400	000163	s	
116	072000	000164	t	
117	072400	000165	u	
118	073000	000166	v	
119	073400	000167	w	
120	074000	000170	x	
121	074400	000171	y	
122	075000	000172	z	
123	075400	000173	{	Left (opening) Brace[5]
124	076000	000174	|	Vertical Line[5]
125	076400	000175	}	Right (closing) Brace[5]
126	077000	000176	~	Tilde, Overline[5]

Notes: [1]This is the standard display representation. The software and hardware in your system determine if the control code is displayed, executed, or ignored. Some devices display all control codes as " ", "@", or space.

[2]Escape is the first character of a special control sequence. For example, ESC followed by "J" clears the display on a 2640 terminal.

[3]Delete may be displayed as "_", "@", or space.

[4]Normally, the caret and underline are displayed. Some devices substitute the up arrow and back arrow.

[5]Some devices upshift lower case letters and symbols (` through ~) to the corresponding upper case character (@ through ∧). For example, the left brace would be converted to a left bracket.

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READER COMMENT SHEET

RTE-6/VM
DEBUG SUBROUTINE
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E Electronic Instruments & Measurement Systems
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Blue Star Ltd.
7 Hare Street
***CALCUTTA** 700 001*
Tel: 12-01-31
Telex: 021-7655
Cable: BLUESTAR
A,M

Blue Star Ltd.
133 Kodambakkam High Road
MADRAS *600 034*
Tel: 82057
Telex: 041-379
Cable: BLUESTAR
A,M

Blue Star Ltd.
Bhandari House, 7th/8th Floors
91 Nehru Place
NEW DELHI *110 024*
Tel: 682547
Telex: 031-2463
Cable: BLUESTAR
A,CH,CM,CS*,E,M*

Blue Star Ltd.
15/16:C Wellesley Rd.
PUNE *411 011*
Tel: 22775
Cable: BLUE STAR
A

Blue Star Ltd.
2-2-47/1108 Bolarum Rd.
SECUNDERABAD *500 003*
Tel: 72057
Telex: 0155-459
Cable: BLUEFROST
A,E

Blue Star Ltd.
T.C. 7/603 Poornima
Maruthankuzhi
TRIVANDRUM *695 013*
Tel: 65799
Telex: 0884-259
Cable: BLUESTAR
E

Computer Maintenance Corporation Ltd.
115, Sarojini Devi Road
SECUNDERABAD *500 003*
Tel: 310-184, 345-774
Telex: 031-2960
*CH***

INDONESIA
BERCA Indonesia P.T.
P.O.Box 496/Jkt.
Jl. Abdul Muis 62
JAKARTA
Tel: 21-373009
Telex: 46748 BERSAL IA
Cable: BERSAL JAKARTA
P

BERCA Indonesia P.T.
P.O.Box 2497/Jkt
Antara Bldg., 17th Floor
Jl. Medan Merdeka Selatan 17
JAKARTA-PUSAT
Tel: 21-344-181
Telex: BERSAL IA
A,CS,E,M

BERCA Indonesia P.T.
P.O. Box 174/SBY.
Jl. Kutei No. 11
SURABAYA
Tel: 68172
Telex: 31146 BERSAL SB
Cable: BERSAL-SURABAYA
A,E,M,P*

IRAQ
Hewlett-Packard Trading S.A.
Service Operation
Al Mansoor City 9B/3/7
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CH,CS

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Hewlett-Packard Ireland Ltd.
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Cardiac Services Ltd.
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M

ISRAEL
Eldan Electronic Instrument Ltd.
P.O.Box 1270
JERUSALEM *91000*
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Tel: 533 221, 553 242
Telex: 25231 AB/PAKRD IL
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Computation and Measurement
Systems (CMS) Ltd.
11 Masad Street
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Telex: 33569 Motil IL
CH,CM,CS,E,P

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I-70124 **BARI**
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W.J. Towell Computer Services
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Computer Information Systems
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E

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P

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CASABLANCA
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NL 5612 LV **EINDHOVEN**
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A,CH**,E,M

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CH,CS,CM,E,P

Northrop Instruments & Systems Ltd.
369 Khyber Pass Road
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AUCKLAND
Tel: 794-091
Telex: 60605
A,M

Northrop Instruments & Systems Ltd.
110 Mandeville St.
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Northrop Instruments & Systems Ltd.
Sturdee House
85-87 Ghuznee Street
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See United Kingdom

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N-5033 **FYLLINGSDALEN** (Bergen)
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UCOsterndalen 16-18
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N-1345 **OCUSTERÅS**
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OMAN
Khimjil Ramdas
P.O. Box 19
MUSCAT
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Telex: 3289 BROKER MB MUSCAT
P

Suhail & Saud Bahwan
P.O.Box 169
MUSCAT
Tel: 734 201-3
Telex: 3274 BAHWAN MB
E

Imtac LLC
P.O. Box 8676
MUTRAH
Tel: 601695
Telex: 5741 Tawoos On
A,C,M

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Mushko & Company Ltd.
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Sector F-6/3
ISLAMABAD
Tel: 824545
Cable: FEMUS Islamabad
*A,E,M,P**

Mushko & Company Ltd.
Oosman Chåmbers
Abdullah Haroon Road
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Tel: 524131, 524132
Telex: 2894 MUSKO PK
Cable: COOPERATOR Karachi
*A,E,M,P**

PANAMA
ElectrOnico Balboa, S.A.
Calle Samuel Lewis, Ed. Alfa
Apartado 4929
PANAMA *5*
Tel: 63-6613, 63-6748
Telex: 3483 ELECTRON PG
A,CM,E,M,P

PERU
Cía Electro Médica S.A.
Los Flamencos 145, San Isidro
Casilla 1030
LIMA *1*
Tel: 41-4325, 41-3703
Telex: Pub. Booth 25306
CM,E,M,P

SAMS
Rio De La Plata 305
SAN ISIDRO
Tel: 419928
Telex: 394 20450 PELIBERTAD
P

PHILIPPINES
The Online Advanced Systems Corporation
Rico House, Amorsolo Cor. Herrera Street
Legaspi Village, Makati
P.O. Box 1510
Metro **MANILA**
Tel: 815-38-11 (up to 16)
Telex: 63274 Online PN
A,CH,CS,E,M

Electronic Specialists and Proponents Inc.
690-B Epifanio de los Santos Avenue
Cubao, **QUEZON CITY**
P.O. Box 2649 Manila
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Telex: 40018, 42000 ITT GLOBE MACKAY BOOTH
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PORTUGAL
Mundinter
Intercambio Mundial de ComAErcio S.A.R.L.
P.O. Box 2761
Av. Antonio Augusto de Aguiar 138
P-LISBON
Tel: (19) 53-21-31, 53-21-37
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M

Soquimica
Av. da Liberdade, 220-2
1298 **LISBOA** *Codex*
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Telex: 13316 SABASA
P

Telectra-Empresa Técnica de Equipmentos Eléctricos S.A.R.L.
Rua Rodrigo da Fonseca 103
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E

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