

TOPS-10 DDT Manual

AA-BH82B-TB

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This manual describes the use of TOPS-10 DDT, the Dynamic Debugging Tool for MACRO-10 programs.

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SOFTWARE:	DDT V44

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PREFACE

MANUAL OBJECTIVES AND AUDIENCE

This manual explains and illustrates the features of TOPS-10 DDT, the debugger for MACRO-10 programs. Although TOPS-10 DDT can be used to debug the compiled code of programs written in higher-level languages, this manual illustrates the use of TOPS-10 DDT to debug programs written in MACRO-10 only.

This manual is both an introduction to the basic functions of TOPS-10 DDT and a reference guide to all TOPS-10 DDT commands and functions.

This manual assumes that the reader is familiar with using TOPS-10, has done some programming in MACRO-10, and is familiar with the format of MACRO-10 instructions.

STRUCTURE OF THIS DOCUMENT

- | This manual has 12 chapters, 1 appendix, and 1 glossary.
 - o Chapter 1 introduces the concept of symbolic debugging and describes the variants of TOPS-10 DDT.
 - o Chapter 2 describes loading TOPS-10 DDT with your program, discusses basic TOPS-10 DDT commands, and illustrates a sample debugging session.
 - o Chapter 3 explains the syntax of a DDT command. Chapter 3 also describes expressions to enter data and explains how TOPS-10 DDT evaluates expressions.
 - o Chapter 4 discusses how to examine and modify a program using TOPS-10 DDT.
 - o Chapter 5 describes the use of TOPS-10 DDT to control program execution: how to start, stop, and monitor the running of a program.
 - o Chapter 6 explains how to perform searches of a program's address space using TOPS-10 DDT.
 - o Chapter 7 discusses the manipulation of program symbols using TOPS-10 DDT.
 - o Chapter 8 describes how to use the TOPS-10 DDT patching function to insert and test a new series of instructions in your program without reassembling the program.

- o Chapter 9 describes the use of FILDDT.
- o Chapter 10 describes the use of EDDT.
- o Chapter 11 describes special-use commands that control physical and virtual addressing. These commands are useful primarily when running EDDT and FILDDT.
- o Chapter 12 describes the use of DDT in non-zero sections (NZS).
- o Appendix A explains DDT and FILDDT error messages.
- o The glossary defines important TOPS-10 DDT terms.

OTHER DOCUMENTS

Other documents to which the reader should have access are:

- o MACRO Assembler Reference Manual
- o LINK Reference Manual
- o TOPS-10 Operating System Commands Manual
- o DECsystem-10/DECSYSTEM-20 Processor Reference Manual
- o TOPS-10/TOPS-20 RSX-20F System Reference Manual

CONVENTIONS

The following conventions are used in this manual in the description of DDT commands and concepts.

- | | |
|-------------------------|--|
| { } | Curly brackets (braces) indicate that the enclosed item is optional. |
| . (period) | The address contained in DDT's location counter; also called the <u>current location</u> . |
| addr | A symbolic location within a program, a symbolic or absolute address in memory, an AC, or ".", the current location. |
| c | A single ASCII or SIXBIT character. |
| expr | Any expression that is legal in DDT. |
| filnam | One or more components of a file specification. |
| instr | Any instruction in the PDP-10 machine instruction set. |
| location sequence stack | A circular stack of memory locations that is used to store the addresses of certain previously referenced locations. |
| n | A numeric argument. |
| page | A page in memory. A page equals 512 words of memory. |

symbol	A symbol name of up to 6 RADIX50 characters.
text	Any string of ASCII or SIXBIT characters.
word	Any 36-bit value occupying one word of memory.
<ESC>	Represents pressing the ESCAPE or ALTMODE key once.
<ESC><ESC>	Represents pressing the ESCAPE or ALTMODE key twice.
<CTRL/X>	Represents pressing a key (represented by X) at the same time as you press the key labeled CTRL.
<BKSP>	represents pressing the BACKSPACE key or <CTRL/H>.
<LF>	Represents pressing the LINE FEED key.
<RET>	Represents pressing the RETURN key.
<TAB>	Represents pressing the TAB key or <CTRL/I>.

Numbers are in octal radix unless otherwise specified.

Examples of interaction between the user and DDT show user input in lowercase and DDT output in uppercase.

The symbols <BKSP>, <CTRL/x>, <ESC>, <LF>, <RET>, and <TAB> always represent user input.

NOTE

The descriptions of many DDT commands list the actions and effects of those commands. The actions and effects may not occur in precisely the order specified, but this has no effect on the user.

CHAPTER 1

INTRODUCTION TO DDT

DDT is a utility program you can use that will help you debug your MACRO-10 programs. This manual describes how to use the DDT utility.

1.1 SYMBOLIC DEBUGGING

It is sometimes difficult to understand precisely the operation of a program by reading the source code. DDT is a tool for interactively examining the operation of a MACRO-10 program while it is running. DDT is useful for finding programming errors (bugs) in programs that do not run correctly. You can also use DDT to analyze the flow of control in a program that is to be revised or rewritten.

With DDT, you can interrupt the execution of your program at locations (breakpoints) you choose, and then examine and modify the program's address space as required. You can execute instructions one-by-one to check whether the effect of each instruction is what is intended. You can then set other breakpoints in your program before continuing execution.

When you refer to program locations and values, DDT allows you to use the symbols that are defined in the program rather than absolute values and addresses. This makes it much easier to refer to the source listing and to find specific locations in memory.

After modifying the program's instructions or data, you can exit DDT and save (with the monitor-level SAVE command) the changed version of the program for further testing.

1.2 TOPS-10 VARIANTS OF DDT

There are several variants of DDT, each useful under specific circumstances or for specific tasks.

The variants of TOPS-10 DDT are:

- o DDT.REL
- o DDT.EXE
- o VMDDT.EXE
- o FILDDT.EXE
- o EDDT.EXE

INTRODUCTION TO DDT

DDT.REL is the relocatable variant of DDT, and can be loaded directly with your MACRO-10 program by using (at TOPS-10 command level) the TOPS-10 command DEBUG command. For example, enter the command string:

```
DEBUG filnam
```

where filnam is the name of your MACRO-10 program (with default extension .MAC). The DEBUG command causes LINK to retain your program symbol table and to merge DDT.REL with your program module(s). See the TOPS-10 Operating System Commands Manual for a description of the DEBUG command.

If you use the DEBUG command with a program written in a higher-level language, such as COBOL or FORTRAN, you will invoke the language-associated debugging tool, such as COBDDT or FORDDT, rather than DDT. To use DDT.REL to debug a program written in a higher-level language, you can explicitly run LINK and load DDT.REL with your program. See the LINK Reference Manual for a description of the /TEST and /DEBUG switches. You can also use the DEBUG command with the /DDT switch, as:

```
DEBUG/DDT filnam
```

where filnam is the name of your program. The /DDT switch tells LINK that you wish to use DDT, rather than the associated debugging tool.

DDT.EXE is a stand-alone variant of DDT that you can use to enter MACRO-10 instructions directly for testing. You run DDT.EXE as a user program by using the TOPS-10 RUN command:

```
R DDT
```

DDT.EXE has system symbols defined as in UUOSYM and MACTEN, and recognizes hardware instructions (for example, MOVE and ADDI) and TOPS-10 UUOs (for example, TTCALL and CORE).

VMDDT.EXE is the variant that is merged with your program when, at TOPS-10 command level, you enter:

```
DDT
```

Your program must be loaded in memory, such as by using the TOPS-10 GET command, or the TOPS-10 RUN command. You can use the DDT command to load VMDDT, whether your program has just been loaded, if it ran to completion, if it crashed, or if you used <CTRL/C> to exit from your program. If JOB DAT location .JBDDT is zero, indicating that there is no other debugger (for example, FORDDT) loaded with your program, the DDT command loads and starts VMDDT. Pages 700-777 are reserved for VMDDT.EXE.

If, during the debugging session, your program executes a CORE UUO to shrink core, the monitor reclaims the memory used by VMDDT, and your program will get an Illegal memory reference error if it reaches a breakpoint.

If your program was not saved with symbols, VMDDT can display only numeric values and may not be of much use. See the LINK Reference Manual for a description of how to use the /SYMSEG and /LOCALS switches to save your program symbols when loading your program.

INTRODUCTION TO DDT

FILDDT.EXE is used to examine and modify disk files and structures, the monitor, and other running jobs. FILDDT is discussed in Chapter 9.

EDDT.EXE is used to debug and patch the monitor. EDDT is discussed in Chapter 10.

CHAPTER 2

GETTING STARTED WITH DDT

2.1 INTRODUCTION

This chapter is an introduction to using DDT. It describes how to load DDT.REL with your program and shows how to perform basic DDT functions. It then illustrates a sample session debugging a simple MACRO-10 program, using basic DDT functions. You can use DDT to debug programs, using only the commands described in this chapter. Once you are familiar with using these commands, you may wish to learn how to use the commands and functions that are described in the rest of the manual, to perform more sophisticated debugging.

The commands used in this chapter are described only in sufficient detail for the debugging task being performed; all commands are thoroughly described in Chapters 3 through 11 of this document.

The best way to learn is by doing. You will learn the commands and techniques discussed in this manual if you use them as you read about them. If you have a MACRO-10 program that you wish to debug, use it to practice the commands discussed here. If not, type in the program X.MAC listed in Figure 2-1.

2.2 LOADING DDT

It is much easier to debug a program when you can use the symbols that are defined in the program. For you to be able to use program symbols, DDT must have access to your program's symbol table. One way to provide this access is to use the TOPS-10 DEBUG command to load DDT.REL with your program and retain your program symbols. Load an existing MACRO-10 program with the TOPS-10 DEBUG command as follows:

```
DEBUG filnam
```

where filnam is the name of your MACRO-10 program. The following appears on your terminal (if your .REL file is older than your .MAC file, MACRO-10 reassembles your program, otherwise the second line does not appear):

```
.DEBUG PROG
MACRO: filnam
LINK: Loading
[LNKDEB DDT execution]
DDT
```

where filnam is the name of your MACRO-10 program (with default extension .MAC). The last line (DDT) indicates that DDT is loaded, and is ready to accept your commands.

GETTING STARTED WITH DDT

2.3 BASIC FUNCTIONS

You must be able to perform certain basic functions to interactively debug a program. Basic DDT functions are:

- o starting the program
- o stopping the program at specified locations
- o examining and modifying memory
- o executing program instructions one-at-a-time
- o continuing execution of the program
- o deleting input
- o exiting DDT

You must give DDT commands to tell DDT what functions to perform. DDT does not wait for a line terminator (such as a carriage return) to indicate the end of your command. Instead, DDT reads your commands character-by-character as you enter them. When you enter a DDT command, you almost never have to press the RETURN key. This manual explicitly indicates the occasions when a command requires you to press the RETURN key.

NOTE

You must press the ESCAPE key as part of entering many DDT commands. This manual uses the symbol <ESC> to indicate where you press the ESCAPE key. When you press the ESCAPE key, DDT displays a dollar sign (\$) on the screen. DDT never displays <ESC> when you press the ESCAPE key.

NOTE

This manual uses the symbols <BKSP>, <ESC>, <LF>, <RET>, and <TAB> to indicate where you press the BACKSPACE, ESCAPE, LINE FEED, RETURN, and TAB keys, respectively. This manual also uses the symbol <CTRL/X> to indicate where you simultaneously press the CONTROL key and the key indicated by X. These symbols ALWAYS indicate where you press the specific keys noted here. You need NEVER enter the characters <BKSP>, <ESC>, <LF>, <RET>, <TAB>, or <CTRL/X>, to enter a DDT command.

Your commands appear on the screen as you type them. Use the DELETE key to delete partially entered commands character-by-character. If you try to delete more characters than you have entered, DDT displays:

XXX

You can delete an entire command line with <CTRL/U>. When you do, DDT displays:

XXX

To exit DDT, enter:

<CTRL/Z>

GETTING STARTED WITH DDT

The other basic DDT functions are described in the rest of this chapter.

2.3.1 Error Conditions

If DDT cannot execute a command, it displays a message to let you know. The message may be only a single character (such as M or U, for Multiply-defined symbol or Undefined symbol), a question mark (?), or a complete message string. For most errors, DDT also sets a pointer to the error string, so that if DDT did not display it, you can enter a command to display the error string. The error string is available for display until another error occurs, when DDT changes the pointer. To display the error string that describes the last DDT error, enter:

<ESC>?

(press the ESCAPE key, followed by a question mark).

2.3.2 Basic Concepts

A very useful DDT concept is that of the current location. The current location is a memory location that you have referenced, either implicitly or explicitly, with your last command, and that is the default point of reference of your next command. The current location can be thought of as the location "where you are". The symbol "." (period) refers to the address of the current location, and can be used as an argument in DDT commands.

The location counter is a DDT pointer that contains the address of the current location. The location counter performs a function similar to that of a bookmark. You can enter a command to display the contents of a specific location but not change the address of the current location, in order to maintain a specific point of reference for your next command. Most DDT commands change the address of the current location, and therefore also change the location counter. The commands that do not change the current location are so indicated.

The open location is a memory word that can be modified by your next command. DDT "opens" the location as a result of a command you give to examine or modify memory. There is never more than one location open at any given time. The open location is usually also the current location.

To find the symbolic address of the current location, enter:

._ (a period followed by an underscore)

This causes DDT to display the following:

ADDR1+n

where ADDR1 is a label defined in your program, and n is the offset of the current location from that label (if the current location is ADDR1, DDT does not display +n).

Another useful DDT concept is that of the current quantity. This is a value that is the contents of the last word that DDT displayed, or the value that you last deposited in memory. The current quantity is the most recent of those values. Many DDT commands use arguments that default to the current quantity.

GETTING STARTED WITH DDT

The location sequence stack is a DDT storage area used to store the addresses of previous current locations. Certain DDT commands store the address of the current location on the location sequence stack. Other DDT commands change the address of the current location to an address that has already been stored on the location sequence stack. The location sequence stack functions in a fashion similar to inserting place-markers in a source code listing, to be able to "get back" to prior references.

2.3.3 Starting and Stopping the Program

When your program is loaded and DDT is ready to accept your commands (as indicated by DDT appearing on the terminal display), you can begin execution of your program at its start address by entering:

```
<ESC>G
```

Unless you set one or more breakpoints before you start the program, your program runs either to completion or until it commits a fatal error. A breakpoint is a location in a program's executable code that has been modified so that if the program attempts to execute the instruction at that location, control passes to DDT before the instruction is executed.

The command to set a breakpoint is:

```
addr<ESC>B
```

where addr is the address at which to stop execution. If the user-program PC reaches addr, DDT interrupts execution of the program before the program executes the instruction at the specified address. When DDT interrupts program execution at a breakpoint, it changes the current location to the breakpoint and opens the current location (the breakpoint).

While program execution is stopped at a breakpoint, you can display and change the contents of instruction and data words, remove breakpoints, set new breakpoints, and execute instructions one at a time (single-step). As you examine memory, you may find an instruction that is incorrect, and modify it. You can also examine and modify data words in memory. After modifying incorrect instructions and data in memory, you can immediately execute the instructions to check the effects of the modifications, without having to reassemble the source code.

Once you have made your changes, you can continue program execution at the place where execution was interrupted, restart the program at the beginning, or start execution at any other location you choose. The program will run to completion, until it reaches a breakpoint, or until it gets a fatal error.

GETTING STARTED WITH DDT

2.3.4 Examining and Modifying Memory

One command to examine memory is:

```
addr/
```

where addr is the address of the memory word you wish to examine (display), and can be numeric or symbolic. DDT displays the contents of the word located at addr. If the opcode field (bits 0-8) of the memory word matches a recognized instruction or user-defined OPDEF, DDT displays the contents of addr as an instruction (or OPDEF). If DDT finds (in the symbol table) any of the values to be displayed, DDT displays those symbols rather than the numeric values. For example, either of the following display lines might appear on your terminal (depending on the address and contents of the word):

```
ADDR1/  MOVE 2,SYM1
```

```
ADDR1+5/ SYM1,,SYM2
```

where ADDR1, SYM1, and SYM2 have been defined in the program.

If you enter a symbol that DDT does not find in the symbol table, DDT sounds the terminal buzzer or bell, and displays U on the screen. If you enter a symbol that is defined as a local symbol in more than one module, DDT sounds the terminal buzzer or bell and displays M. You can eliminate the multiply-defined symbol problem by "opening" the symbol table of the module in which the correct symbol is defined. See Chapter 7 (Manipulating Symbols in DDT) for more information.

When searching for a symbol to display, DDT uses global symbols in preference to local symbols. However, DDT searches the "open" symbol table first, and treats local symbols found in the open symbol table as global symbols. If DDT finds only a local symbol that is not in the open symbol table, DDT displays the symbol with a pound-sign (#) appended to the symbol. For example, DDT might display:

```
ADDR#/  MOVE 2,SYM1
```

See Chapter 7 (Manipulating Symbols in DDT) for more information on symbols and symbol tables.

The command addr/ changes the current location to addr and opens the word at addr.

If you omit addr from an examine-memory command, such as addr/, DDT uses the current quantity to determine the address of the location to display. For example, after DDT displays the contents of ADDR1+5 as above, if you enter "/", DDT displays the contents of the word located at SYM2. The display line then appears:

```
ADDR1+5/  SYM1,,SYM2  /  value
```

where value is the contents of the word located at SYM2. By default, DDT displays value symbolically if it can.

The command / by itself (without addr) does not change the current location. Both forms of the / command open the location displayed, enabling you to modify the location with your next command.

GETTING STARTED WITH DDT

Another very useful command for examining memory is <TAB>. This command starts a new display line before displaying the contents of addr, making the display easier to read. For example, if you enter <TAB> after DDT displays the address and contents of ADDR1+5 (as above) on your terminal, the terminal display appears:

```
ADDR1+5/  SYM1,,SYM2  <TAB>
SYM2/    value
```

where value is the contents of the word located at SYM2. <TAB> does not appear on the screen, but is shown above to indicate where you press the <TAB> key. <TAB> changes the current location to SYM2 and opens the word at SYM2. In this example, the current quantity becomes value.

<TAB> also stores the address of the current location (ADDR1+5) on the location sequence stack before changing the current location to the location just displayed (SYM2). DDT uses the location sequence stack to "remember" previous values of the location counter. To "get back" to the previous current location, enter:

```
<ESC><RET>
```

In the above example, after you press <TAB> at ADDR1+5, DDT displays the contents of SYM2 and changes the current location to SYM2. When you enter <ESC><RET>, DDT changes the current location to ADDR1+5, opens the location at ADDR1+5, and again displays the contents of ADDR1+5.

If you use the command addr<TAB>, DDT deposits addr in the open location and closes the location before opening the location at addr and displaying its contents. <TAB> by itself does not deposit anything, but does save the current location on the location sequence stack, making <TAB> more useful than / (slash by itself).

You can display and open the word after the current location by entering:

```
<LF>
```

DDT changes the current location to the next word in memory, starts a new line, and displays the address of the (new) current location (as a symbol or a symbol plus an offset, if it can find a corresponding symbol in the symbol table), displays the contents of the current location, and opens the current location. For example, to display the next word in memory after ADDR1+5, enter:

```
<LF>
```

DDT changes the current location to ADDR1+6, starts a new line, and displays the address and contents of ADDR1+6. The screen display then appears as follows:

```
ADDR1+5/  SYM1,,SYM2  <LF>
ADDR1+6/  -1,,SYM3
```

Note that DDT does not display the characters <LF>. <LF> does not affect the location sequence stack.

Entering another <LF> causes DDT to display and open the next word.

GETTING STARTED WITH DDT

To display and open the word previous to the current location, enter:

```
<BKSP>
```

DDT changes the current location to the previous word, starts a new line, displays the address and contents of the (new) current location, and opens the current location. <BKSP> does not affect the location sequence stack. For example, if you enter <BKSP> to open and display the location before ADDR1+5, the screen appears as follows:

```
ADDR1+5/  SYM1,,SYM2  <BKSP>
ADDR1+4/  -3,,SYM2
```

Note that <BKSP> does not appear on the screen.

To change the contents of the open location, enter:

```
value<RET>
```

where value can be an instruction, a symbol, or a numeric expression.

For example, if you enter the command LABL2/, DDT displays the contents of the memory word at LABL2, and "opens" that word. If the word at LABL2 contains:

```
MOVE 1,SYM1
```

and you wish to change SYM1 to SYM2, enter:

```
MOVE 1,SYM2<RET>
```

DDT stores the new instruction in the location at LABL2 and "closes" the location. DDT does NOT display <RET>. The terminal display appears as follows (your input is in lowercase):

```
labl2/  MOVE 1,SYM1  move 1,sym2<RET>
```

The current location is still LABL2, but there is no open location. To check whether the instruction is now correct, you can enter:

```
./
```

to display the contents of the current location. The screen display now appears (your input is in lowercase):

```
labl2/  MOVE 1,SYM1  move 1,sym2<RET>
./  MOVE 1,SYM2
```

After entering a command to display and open a location, if you enter:

```
value<LF>
```

DDT stores the new value, changes the current location to the next location in memory, starts a new display line and opens and displays the new current location. The example above would then appear as follows (your input is in lowercase):

```
labl2/  MOVE 1,SYM1  move 1,sym2<LF>
LABL2+1/  CONTENTS
```

where CONTENTS is the value stored at LABL2+1.

GETTING STARTED WITH DDT

2.3.5 Executing Program Instructions

When you have interrupted program execution at a breakpoint, you can execute the next instruction (the one at the breakpoint), by entering:

```
<ESC>X
```

DDT executes the instruction, displays the results of executing the instruction, and displays the address and contents of the next instruction to be executed. This command changes the current location to the next instruction to be executed. For example, assume that the next instruction to be executed is located at LABEL1, which contains:

```
MOVE 1,VARIBL
```

If the word at VARIBL contains SYM1, when you enter <ESC>X, DDT starts a new line and displays:

```
1/ SYM1 VARIBL/ SYM1  
LABEL1+1/ instr
```

where instr is the contents of LABEL1+1, and is the next instruction to be executed. You can continue to execute instructions one-at-a-time by entering successive <ESC>X commands. This is known as single-stepping.

To execute a subroutine, enter:

```
<ESC><ESC>X
```

DDT executes the subroutine and returns control to you if the subroutine returns to a location +1, +2, or +3 from the instruction that calls the subroutine. DDT changes the current location to the address of the next instruction to be executed.

To continue execution of the program until the next breakpoint or until program completion, enter:

```
<ESC>P
```

DDT starts the program running again, beginning with the next instruction to be executed. If you did not single-step any instructions, the program begins by executing the instruction at the breakpoint. If you have executed any instructions by single-stepping, the program continues where you stopped. The effect is as if the program were running without DDT in control.

2.4 A SAMPLE DEBUGGING SESSION USING DDT

This section describes a debugging session using DDT. The program being debugged is X.MAC, shown in Figure 2-1. The program and the sample session are for illustration only. There are many styles of programming and debugging, and these examples are descriptive rather than prescriptive in intent.

You will understand this section and learn the commands described more easily if you type in the program listed in Figure 2-1 and use the commands as they are described.

GETTING STARTED WITH DDT

Figure 2-1: Sample Program X.MAC

```

SEARCH  UUOSYM
TITLE   X

R0=0                                ;AC0
IDX=6                                  ;INDEX REGISTER
P=17                                  ;STACK COUNTER

START:: MOVE    P,PWORD                ;Set up stack counter
        MOVEI   IDX,TABLE1              ;Address of table with X & Y
        PUSHJ   P,ADDEM                  ;Do the addition
        MOVEI   IDX,TABLE1              ;Address of table
        MOVE    R0,ANSWER(IDX)          ;Answer to R0
        JFCL    0
        EXIT                                ;All done!
ADDEM:  MOVE    R0,X(IDX)                ;Load X
        ADD     R0,Y(IDX)                ;X + Y
        MOVE    R0,ANSWER(IDX)          ;Store answer
        POPJ    P,                      ;Return

TABLE1: BLOCK   3                       ;3 words
X==0                                           ;Offset for X
Y==1                                           ;Offset for Y
ANSWER==2                                       ;Offset for answer
STKSIZ==10                                      ;Stack size
PWORD:  IOWD  STKSIZ,STACK                    ;Stack pointer
STACK:  BLOCK STKSIZ                          ;Stack
        END    START

```

Figure 2-2 is an annotated session debugging X.MAC, the program in Figure 2-1. In the annotated session, the DDT terminal display is on the left, user input is in the center in lowercase, and explanatory comments about the session are on the right. This is not always the way it appears on the terminal. Figure 2-3 shows the session as it actually appears on the terminal.

The program is designed to pass the address of a table to a subroutine. The table contains three elements. The subroutine is to add the first two elements of the table and store the result in the third element before returning to the main program. There are no input or output routines in the program. The table is initialized using DDT, and the result is checked while in DDT.

NOTE

DDT does not display <LF>, <RET>, or <TAB>. These are shown in the sample session to indicate user input.

NOTE

DDT does not display the AC field of an instruction if it is zero. This means that if your program contains the instruction MOVE R0,LABL1, where R0=0, DDT displays the instruction as MOVE LABL1.

GETTING STARTED WITH DDT

Figure 2-2: Annotated Debugging Session

SCREEN DISPLAY	USER INPUT	EXPLANATION
.		TOPS-10 prompt.
	debug x<RET>	Begin the session by entering "debug x<RET>", where x is the name of your MACRO program.
MACRO: X LINK: Loading [LNKDEB DDT execution] DDT		MACRO reassembles your program (if needed), and LINK loads your program with DDT. DDT displays the "DDT" prompt.
	start/	Begin examining code at label "START".
MOVE P,PWORD#		DDT displays the instruction at START.
	<LF>	Press <LF> to display the next instruction.
DDTEND+1/ MOVEI IDX,TABLE1#		The first symbol in this program happens to coincide with DDTEND, a DDT symbol. When DDT scans the symbol table, it finds DDTEND before it finds START, and displays DDTEND instead. DDT still accepts START as an input symbol. Also note the pound-sign (#) appended to TABLE1 and PWORD. PWORD and TABLE1 are local symbols that are not in the open symbol table.
	ddtend<ESC>k	Enter ddtend<ESC>k to suppress DDT typeout of symbol DDTEND. DDT will display START rather than DDTEND from now on.
	x<ESC>:	Enter the module name (X) followed by <ESC> and a colon to open the symbol table associated with X. DDT will not append any more pound-signs.

GETTING STARTED WITH DDT

Figure 2-2: Annotated Debugging Session (Cont.)

SCREEN DISPLAY	USER INPUT	EXPLANATION
	<TAB>	Press <TAB> to start a new display line, evaluate the current quantity as if it were an instruction, and display the contents of the location addressed by the Y field of the instruction. (Entering / (slash) displays the same word as <TAB>, but does not start a new line.) <TAB> also saves your place (like a bookmark) on the location sequence stack, so you can get back here easily.
TABLE1/ 0		When you enter the <TAB> command, DDT displays the address and the contents of the location. The first element of the table contains zero. The <TAB> command also opens the location.
	2<LF>	Enter "2" followed by <LF> to deposit the value "2" in the first element, and to open and display the second element.
TABLE1+1/ 0		The second element contains zero.
	3<LF>	Enter "3" followed by <LF> to deposit the value "3" in the second element and open and display the third element. The addition to be performed by the program is 2+3.
TABLE1+2/ 0		The third element (the answer) contains zero.
	<ESC><RET>	Press <ESC>, then press <RET> to return to the address you saved on the location sequence stack.
START+1/ MOVEI IDX, TABLE1		DDT displays the address and contents of the last location you displayed before you entered <TAB>.
	<LF>	Press <LF> to look at the next location.

GETTING STARTED WITH DDT

Figure 2-2: Annotated Debugging Session (Cont.)

SCREEN DISPLAY	USER INPUT	EXPLANATION
START+2/ PUSHJ P,ADDEM		This is the call to the subroutine that does the computation.
	.<ESC>b	Enter ".", press <ESC>, and enter "b" to set a breakpoint at the current location.
	<ESC>g	Enter <ESC>g to start program execution.
\$1B>>START+2/ PUSHJ P,ADDEM		DDT displays the breakpoint number, the address of the breakpoint, and the instruction at the breakpoint. This instruction has not yet been executed.
	<ESC><ESC>x	Press <ESC> twice, then enter "x" to let DDT execute the subroutine.
START+3/ MOVEI IDX,TABLE1		DDT returns from the subroutine at the next instruction, and displays the address and contents of the instruction. If there is a "skip return", DDT displays "<SKIP>" if the program skipped one instruction. If the program skips 2 or 3 instructions, DDT displays "<SKIP n>", where n is the number of instructions skipped.
	<ESC>x	Press <ESC> and enter "x" to execute the instruction.
IDX/ TABLE1 TABLE1		DDT displays the address and contents of IDX (the result of executing the instruction), and also displays "TABLE1" (the result of evaluating the Y field of the instruction).
START+4/ MOVE 2(IDX)		DDT then starts a new line and displays the address and contents of the next instruction. Note that DDT does not display the zero in the AC field of the instruction.

GETTING STARTED WITH DDT

Figure 2-2: Annotated Debugging Session (Cont.)

SCREEN DISPLAY	USER INPUT	EXPLANATION
	<ESC><TAB>	Press <ESC>, then <TAB> to display the contents of the location addressed by the instruction, using any indexing and indirection. (If you omit <ESC>, DDT uses only the Y field, without indexing and indirection.)
TABLE1+2/ 0		The location addressed by the instruction is TABLE1+2, and its contents is zero. This is the table element that contains the answer, which should be 5.
	<BKSP>	Press <BKSP> to see the previous element in the table.
TABLE1+1/ 3		This element contains 3. That is correct.
	<BKSP>	Press <BKSP> again to check the previous element.
TABLE1/ 2		This element contains 2. That is also correct. One way to find the error is to single-step through the program.
	start<ESC>b	Enter "start", press <ESC>, and enter "b" to set a breakpoint at the beginning of the program.
	<ESC>g	Press <ESC> and enter "g" to start the program again.
\$2B>>START/ MOVE P,PWORD		DDT displays the breakpoint number, and the address and contents of the instruction at the breakpoint.
	<ESC>x	Press <ESC>, then enter "x" to execute the instruction. This instruction moves a memory word to a register.
P/ -10,,PWORD PWORD/ -10,,PWORD		DDT displays the address and new contents of the register, and the address and contents of the memory word.

GETTING STARTED WITH DDT

Figure 2-2: Annotated Debugging Session (Cont.)

SCREEN DISPLAY	USER INPUT	EXPLANATION
START+1/ MOVEI IDX, TABLE1		DDT then displays the address and contents of the next instruction.
	<ESC>x	Press <ESC>, then enter "x" to execute this instruction, which moves an immediate value to a register.
IDX/ TABLE1 TABLE1		DDT displays the address and new contents of the register, and the immediate value.
START+2/ PUSHJ P, ADDEM		DDT then displays the address and contents of the next instruction.
	<ESC>x	Press <ESC>, then enter "x" to execute the instruction.
P/ -7,,STACK		DDT displays the address and new contents of the stack pointer used by the PUSHJ.
<JUMP>		DDT displays "<JUMP>" if the change in PC is less than one or greater than 4.
ADDEM/ MOVE 0 (IDX)		DDT displays the address and contents of the next instruction to be executed.
	<ESC>x	Press <ESC> and enter "x" to execute the instruction.
0/ 2 TABLE1/ 2		The instruction moved the contents of the word at TABLE1 (which is 2) to AC0. Looks OK so far.
ADDEM+1/ ADD 1 (IDX)		DDT displays the next instruction.
	<ESC>x	Press <ESC> and enter "x" to execute the instruction.
0/ 5 TABLE1+1/ 3		The instruction added the contents of the word at TABLE1+1 (which is 3) to AC0, which now contains 5. OK.
ADDEM+2/ MOVE 2 (IDX)		DDT displays the next instruction.
	<ESC>x	Press <ESC> and enter "x" to execute the instruction.

GETTING STARTED WITH DDT

Figure 2-2: Annotated Debugging Session (Cont.)

SCREEN DISPLAY	USER INPUT	EXPLANATION
0/ 0 TABLE1+2/ 0		The instruction moved the contents of the word at TABLE1+2 to AC0. The MOVE instruction at ADDEM+2 should be MOVEM.
ADDEM+3/ POPJ P,0		DDT displays the next instruction (as a result of the <ESC>x).
	<BKSP>	Press <BKSP> to display and open the location with the incorrect instruction.
ADDEM+2/ MOVE 2(IDX)		DDT displays the previous instruction. This is the incorrect instruction.
	movem r0,answer(idx)<RET>	
		Enter the new instruction and press <RET>.
	./	Check the current location to see what you deposited.
MOVEM 2(IDX)		Looks OK.
	.<ESC>b	Set a breakpoint at ".", the current location.
	<ESC>g	Restart the program at the beginning.
\$2B>>START/ MOVE P,PWORD		DDT displays the breakpoint information.
	<ESC>p	Press <ESC> and enter "p" to proceed from breakpoint 2 to the next breakpoint.
\$1B>>START+2/ PUSHJ P,ADDEM		DDT displays the breakpoint information.
	<ESC>p	Proceed from breakpoint 1.
\$3B>>ADDEM+2/ MOVEM 2(IDX)		DDT displays the breakpoint information. This is the instruction you changed.
	<ESC>x	Single-step the instruction to watch what it does.
0/ 5 TABLE1+2/ 5		The instruction moves the contents of AC0 to the word at TABLE1+2. OK!!

GETTING STARTED WITH DDT

Figure 2-2: Annotated Debugging Session (Cont.)

SCREEN DISPLAY	USER INPUT	EXPLANATION
ADDEM+3/ POPJ P,0		DDT also displays the address and contents of the next instruction.
	start+4<ESC>b	Set a breakpoint at START+4 to check the results.
	<ESC>p	Proceed from breakpoint 3.
\$4B>>START+4/ MOVE 2(IDX)		DDT displays the breakpoint information.
	<ESC>x	Single-step the instruction.
0/ 5 TABLE1+2/ 5		The instruction moves the contents of the word at TABLE1+2 to AC0. The new value of AC0 is 5. OK!
START+5/ JFCL 0		DDT displays the address and contents of the next instruction.
	<CTRL/Z>	Quit. Back at TOPS-10 command level.

GETTING STARTED WITH DDT

Figure 2-3 shows the session as it actually appears on the terminal screen. Again, user input is in lowercase. Comments on the right indicate where you enter characters that do not echo.

Figure 2-3: Terminal Display of Debugging Session

```
.debug x
MACRO: X
LINK: Loading
[LNKDEB DDT execution]
DDT
start/ MOVE P,PWORD#
DDTEND+1/ MOVEI IDX,TABLE1# ddtend$k x$: Enter <LF>.
TABLE1/ 0 2 Enter <TAB>.
TABLE1+1/ 0 3 Enter <LF>.
TABLE1+2/ 0 $ Enter <ESC><RET>.
START+1/ MOVEI IDX,TABLE1 Enter <LF>.
START+2/ PUSHJ P,ADDEM . $b $g
$1B>>START+2/ PUSHJ P,ADDEM $$x
START+3/ MOVEI IDX,TABLE1 $x
IDX/ TABLE1 TABLE1
START+4/ MOVE 2(IDX) $ Enter <ESC><TAB>.
TABLE1+2/ 0 Enter <BKSP>.
TABLE1+1/ 3 Enter <BKSP>.
TABLE1/ 2 start$b $g
$2B>>START/ MOVE P,PWORD $x
P/ -10,,PWORD PWORD/ -10,,PWORD
START+1/ MOVEI IDX,TABLE1 $x
IDX/ TABLE1 TABLE1
START+2/ PUSHJ P,ADDEM $x
P/ -7,,STACK
<JUMP>
ADDEM/ MOVE 0(IDX) $x
0/ 2 TABLE1/ 2
ADDEM+1/ ADD 1(IDX) $x
0/ 5 TABLE1+1/ 3
ADDEM+2/ MOVE 2(IDX) $x
0/ 0 TABLE1+2/ 0
ADDEM+3/ POPJ P,0 Enter <BKSP>.
ADDEM+2/ MOVE 2(IDX) movem r0,answer(idx) Enter <RET>.
./ MOVEM 2(IDX) . $b $g
$2B>>START/ MOVE P,PWORD $p
$1B>>START+2/ PUSHJ P,ADDEM $p
$3B>>ADDEM+2/ MOVEM 2(IDX) $x
0/ 5 TABLE1+2/ 5
ADDEM+3/ POPJ P,0 start+4$b $p
$4B>>START+4/ MOVE 2(IDX) $x
0/ 5 TABLE1+2/ 5
START+5/ JFCL 0 ^Z
.
```

GETTING STARTED WITH DDT

2.5 PROGRAMMING WITH DDT IN MIND

There are a few MACRO-10 programming techniques that make debugging with DDT easier. These techniques primarily concern the use of labels and symbols.

Labels that meaningfully describe (perhaps mnemonically) the function of the code are more helpful when examining code and setting breakpoints than labels that are alphanumerically coded (such as A0001).

When using symbols as offsets into tables, you can prevent DDT from displaying the offset symbol in place of the symbol's numeric value if you define the symbol in this way:

```
symbol==expression
```

Symbol is still entered in the symbol table, and you can use symbol as input to DDT, but DDT does not display symbol on output.

For example, if you have defined:

```
OFFSET==3
```

DDT displays the contents of a word that contains the value of 3 as:

```
addr/ 3
```

rather than:

```
addr/ OFFSET
```

where addr is the address of the word. See the MACRO Assembler Reference Manual for more information about defining symbols.

CHAPTER 3
DDT COMMAND FORMAT

3.1 COMMAND SYNTAX

The complete syntax of a DDT command is:

```
{arg1<}{arg2>}{arg3}{<ESC>{<ESC>}{arg4}}c{arg5}
```

where `arg1`, `arg2`, `arg3`, `arg4`, and `arg5` are arguments to the command `c`. `Arg1`, `arg2`, and `arg3` can be any legal DDT expression. `Arg1` must be followed by a left angle bracket (<), and `arg2` must be followed by a right angle bracket (>). `Arg4` can only be a number. `Arg5` is a text argument of the form:

```
/text/      or      c<ESC>
```

where `text` is a string of characters, the slashes (/) are delimiters that can be any character not contained in `text`, and `c` is a single character.

DDT commands never use all five arguments. Each argument is optional or required according to the syntax of the specific command. Most DDT commands are not more complicated than:

```
arg3<ESC>c      or      arg3<ESC>arg4c
```

You can enter alphabetic commands and text arguments in uppercase or lowercase.

An argument to a command can be the result of executing another command. For example, you can enter a command to evaluate a text string, and then enter another command to deposit in memory the result of evaluating the text string. The entire command line would be:

```
"/abcd/<RET>
```

where `/abcd/` is the argument to the command `"` (quotation mark). The function of the quotation mark command is to evaluate the string (`abcd`) within the delimiters (/) as a left-justified ASCII string. The left-justified ASCII string `abcd` is then the argument to the command `<RET>` (entered by pressing the RETURN key). The function of the `<RET>` command is to deposit an argument (in this case, the string `abcd`) into the open location. The `"` command is described in this chapter, and the `<RET>` command is described in Chapter 4 (Displaying and Modifying Memory).

DDT COMMAND FORMAT

Most commands produce results that are immediately visible, such as commands that display the contents of memory locations. However, commands such as those that invoke search functions or those that evaluate text expressions (as above) may not produce immediately visible results. If you enter a question mark (?) while DDT is performing a function invoked by one of these commands, DDT displays a message that tells you what DDT is currently doing. For example, such a message might be:

```
Searching: addr/ value
```

where addr is the address that DDT is to next test as part of a search, and value is the contents of the memory location at addr. Still other commands return values that DDT does not display, but can use as arguments to other commands.

3.2 INPUT TO DDT

You enter arguments to DDT as expressions. An expression can be a single value, or a combination of two or more values with one or more operators.

3.2.1 Values in DDT Expressions

Values in DDT expressions can be:

- o octal or decimal integers
- o floating point numbers
- o symbols
- o values that are returned by commands
- o text

To enter an octal integer value, simply enter the integer in octal digits. For example:

```
70707065
```

To enter a decimal integer value, enter the integer in decimal digits and follow the value with a decimal point. For example:

```
9876.
```

To enter a floating point number, use regular or scientific notation. For example, you can enter the value .034 as one of the following:

```
.034  
3.4E-2
```

Note that 1. is a decimal integer, while 1.0 is a floating point number.

DDT COMMAND FORMAT

To enter a symbol as a value in an expression, type in the symbol name as defined in your program. To enter an undefined symbol that you can define later, enter:

symbol#

where symbol is the symbol that you will later define. See Chapter 7 (Manipulating Symbols in DDT) for more information about using undefined symbols.

You can enter a command that returns a value as a value in an expression. DDT commands that return values and the values they return are listed in Table 3-1.

Table 3-1: Commands That Return Values

COMMAND	VALUE RETURNED	VALUE ALSO KNOWN AS
.	The address of the current location.	.
<ESC>.	The address of the next user program instruction to be executed.	\$.
<ESC><ESC>.	The previous value of "<ESC>.".	\$\$.
<ESC>nB	The address of the DDT location that contains the address of breakpoint n.	\$nB
<ESC>nI	The address of the DDT location that contains the saved machine state flags (user-program context).	
<ESC>nM	The address of DDT "mask" n.	
<ESC>Q	The current quantity.	\$Q
<ESC><ESC>Q	The current quantity, with halves swapped.	\$\$Q
<ESC>nU	The address of the DDT location that contains the argument (or default) that was given in the virtual addressing command: <code>expr<ESC>nU</code> .	

The commands <ESC>nB, <ESC>nI, <ESC>nM, and <ESC>nU, return values that are the addresses of locations internal to DDT, which contain information that you can use and modify. For brevity, these commands are said to address those internal DDT locations.

For example, the command <ESC>nB returns (but does not display) the address of the DDT location that contains the address of breakpoint n, and the command `addr/` (address followed by slash) displays the contents of the location at `addr`. To display the address of breakpoint n, enter:

<ESC>nB/

where you enter the command <ESC>nB as the expression for DDT to evaluate as addr.

DDT COMMAND FORMAT

You can enter text to be interpreted in the following ways:

- o left-justified ASCII strings
- o left-justified SIXBIT strings
- o single right-justified ASCII characters
- o single right-justified SIXBIT characters
- o RADIX50 words

You can enter text expressions in uppercase or lowercase. DDT translates strings to uppercase for SIXBIT or RADIX50 text as required.

The term long text string refers to an expression in a DDT command that is a string of text characters that requires more than one 36-bit expression for full evaluation. You can enter long text strings in SIXBIT and ASCII as DDT expressions. If you use a long text string as an expression, DDT assumes that you will enter a command that deposits the expression in memory.

DDT evaluates the string one 36-bit expression at a time. After evaluating the first 36-bit expression, DDT deposits the expression in the open location, closes the open location, and opens the next location.

DDT then evaluates the next 36-bit expression contained in the string, and deposits that expression in the (new) open location. This process continues until you enter c, the command. If you enter a command that does deposit to memory, DDT deposits the final 36-bit expression in the open location, and updates the location counter according to the rules of that particular command. The current quantity is the last 36-bit expression that DDT evaluated.

If you do not enter a command that deposits to memory, DDT uses, as the argument to the command, the 36-bit expression that was last evaluated. All other 36-bit expressions that were evaluated as part of the string have been deposited, and the current and open locations were updated accordingly. The current quantity is then the last 36-bit expression that DDT evaluated.

If there is no open location when you begin typing the long text string, DDT evaluates only the first 36-bit expression, ignores the rest of the string, and uses the first 36-bit expression as the argument to the command. The current quantity is then the first 36-bit expression that DDT evaluated in the string. If you enter a command that deposits to memory, it has no effect because there was no open location.

The syntax to enter an ASCII string is:

```
"/text/
```

where text is the string, and the slashes (/) represent any printing character that is not contained within text. DDT evaluates the string as a series of 36-bit expressions, each in 7-bit ASCII format (left-justified), with all unused bits reset.

DDT COMMAND FORMAT

For example, if you enter:

```
"+abc/def+
```

DDT evaluates one 36-bit expression as the 7-bit ASCII string abc/d in bits 0-34, and bit 35 reset. If there is no open location, DDT uses that expression as the argument to the command, and that expression becomes the current quantity.

If there is an open location, DDT deposits abc/d in the open location, closes it, and opens the next location in memory. DDT then evaluates a second 36-bit expression as the 7-bit ASCII string ef in bits 0-13, and bits 14-35 reset. The last 36-bit expression evaluated becomes the current quantity.

NOTE

You cannot use this format to enter an ASCII string that begins with the ESCAPE character, because <ESC> terminates the command that enters a single right-justified ASCII character (in this case, your intended delimiter).

The syntax to enter a SIXBIT string is:

```
<ESC>"/text/
```

where text is the string, and the slashes (/) represent any printing character that is not contained within text. DDT evaluates the string as a series of 36-bit expressions, each in SIXBIT format (left-justified), with any unused bits in the last 36-bit expression reset. DDT translates lowercase characters to uppercase; all other non-SIXBIT characters cause DDT to sound your terminal buzzer or bell and display a question mark.

For example, if you enter:

```
<ESC>">qwertyu>
```

DDT evaluates one 36-bit expression as the SIXBIT string QWERTY in bits 0-35. If there is no open location, DDT uses that expression as the argument to the command, and that expression becomes the current quantity.

If there is an open location, DDT deposits QWERTY in the open location, closes it, and opens the next location in memory. DDT then evaluates a second 36-bit expression as the SIXBIT character U in bits 0-5, with bits 6-35 reset. The last 36-bit expression evaluated becomes the current quantity.

NOTE

You cannot use this format to enter a SIXBIT string that begins with the ESCAPE character, because <ESC> terminates the command that enters a single right-justified SIXBIT character (in this case, your intended delimiter).

The syntax to enter a right-justified ASCII character is:

```
"c<ESC>
```

where c is the character. DDT evaluates this as one 36-bit expression with the 7-bit ASCII character c in bits 29-35, and bits 0-28 reset.

DDT COMMAND FORMAT

The syntax to enter a right-justified SIXBIT character is:

```
<ESC>"c<ESC>
```

where c is the character. DDT evaluates one 36-bit expression with the SIXBIT character c in bits 30-35, and bits 0-29 reset. DDT translates lowercase characters to uppercase; all other non-SIXBIT characters cause DDT to sound your terminal buzzer or bell and display a question mark.

The syntax to enter a RADIX50 word is:

```
text<ESC>5"
```

where text is any string of RADIX50 characters up to six characters long. DDT evaluates one 36-bit expression with bits 0-3 reset and the RADIX50 string text in bits 4-35. DDT ignores any characters in text after the sixth.

For example, if you enter:

```
poiuytr<ESC>5"
```

DDT evaluates one 36-bit expression with bits 0-3 reset and the RADIX50 string POIUYT in bits 4-35. DDT ignores the character r. DDT translates lowercase characters to uppercase. Characters in text not in the RADIX50 character set that are DDT commands use, as an argument to the command, any characters already entered. Characters in text not in the RADIX50 character set that are not DDT commands cause DDT to sound your terminal buzzer or bell and display a question mark.

3.2.2 Operators in DDT Expressions

When you enter an expression, DDT evaluates the expression to create a 36-bit quantity but does not necessarily use all 36 bits when it executes the command. For example, you can enter a complete MACRO instruction when giving an argument to a command that requires an address, but DDT uses only the address specified by the instruction (and ignores the rest of the evaluated expression) when it executes the command.

Table 3-2 lists DDT's expression operators and the effects those operators produce on the evaluation. The term value so far represents the accumulated 36-bit value resulting from evaluation of the expression to that point.

DDT COMMAND FORMAT

Table 3-2: Effects of Operators When Evaluating Expressions

OPERATOR	EFFECT ON EVALUATION
+	Add the 36-bit value on the left to the 36-bit value on the right, using two's complement addition.
-	Subtract the 36-bit value on the right from the 36-bit value on the left, using two's complement subtraction.
*	Multiply the 36-bit value on the left by the 36-bit value on the right, using PDP-10 full-word integer multiplication. DDT uses only the low-order 36 bits of the result.
' (apostrophe)	<p>Divide the 36-bit value on the left by the 36-bit value on the right, using PDP-10 full-word integer division. DDT ignores any remainder.</p> <p style="text-align: center;">NOTE</p> <p>Apostrophe is DDT's division operator. / (slash) is a DDT command to examine memory, and is never used in DDT to indicate division.</p>
space	Add the previous expression (normally an opcode) to the value so far, and add the low-order 18 bits of the value at the right of the space to the low-order 18 bits of the value so far. DDT ignores carries resulting from the addition, and does not change the left half of the value so far.
, (comma)	<p>If you are entering an I/O instruction, shift the low-order 18 bits of the expression at the left of the comma 26 bits to the left (to the device field of the instruction), otherwise shift the low-order 18 bits of the expression at the left of the comma 23 bits to the left (to the A field of an instruction). Then logically OR the result into the value so far.</p> <p style="text-align: center;">NOTE</p> <p>DDT does not check whether the value at the left of the comma is a legitimate device or AC address, and may overwrite other parts of the instruction.</p>

DDT COMMAND FORMAT

Table 3-2: Effects of Operators When Evaluating Expressions (Cont.)

OPERATOR	EFFECT ON EVALUATION
()	<p>Swap the halves of the expression within the parentheses and add the resulting expression to the value so far. This makes it possible to enter an instruction that uses an index register.</p> <p style="text-align: center;">NOTE</p> <p>DDT does not check whether the value within the parentheses is a legitimate AC address, and may overwrite other parts of the instruction.</p>
@	<p>Assume the expression is an instruction and set the indirect bit (bit 13) of the value so far.</p>
,, (two commas)	<p>Move the low-order bits of the expression at the left of the commas to bits 0-17 and build a new 18-bit expression in the right half.</p>

The nonarithmetic operators allow you to enter expressions in instruction format as well as in data format.

To enter an instruction, format the instruction as you would in a MACRO-10 program. For example:

```
MOVE R4,@VAR1+OFFSET(R5)
```

NOTE

Follow an opcode (such as MOVE) with a space, not a <TAB>.

To enter halfwords, enter the values (numbers or symbols) separated by two commas (,,). The halfwords can be symbolic or absolute values. For example:

```
-1,,SYM1
```

NOTE

DDT is not designed to evaluate complicated arithmetic expressions. The nonarithmetic operators are implemented to enable DDT to evaluate expressions you enter as MACRO-10 instructions and halfwords. Using values and operators for other purposes may not produce the results you intend.

DDT COMMAND FORMAT

3.3 COMMAND FILES

If you frequently use DDT or FILDDT to debug the same file (such as the monitor), and execute the same commands each time (such as loading symbols, suppressing symbols, applying patches, and setting virtual addressing conditions), you can save time by creating a file that contains these commands. At any time that you are in DDT you can give the command:

```
<ESC>Y
```

to indicate that you wish to load a command file. DDT prompts:

```
File:
```

Enter the file specification, followed by <RET>. You can enter a complete TOPS-10 file specification. DDT reads the file and executes the commands. If you append /A after the file specification, DDT stops executing the command file if it encounters any errors while executing the commands in the file. If you do not use the /A switch, DDT executes all legal commands in the control file regardless of any errors.

An alternate form of the command is:

```
filnam<ESC>Y
```

where filnam is a SIXBIT file name up to six characters long, with default device DSK: and default extension .DDT. For example, to have DDT execute the DDT commands contained in file DSK:PROG.DDT, enter:

```
<ESC>"/PROG/<ESC>Y
```

The delimiters (/) can be any character not in filnam.

If bit 15 of the TTY control mask is reset, DDT displays the commands and resulting output as it executes them. If bit 15 is set, DDT suppresses the display. The command <ESC>1M returns the address of the DDT location that contains the TTY control mask. See Chapter 4 (Displaying and Modifying Memory) for more information about the TTY control mask.

CHAPTER 4

DISPLAYING AND MODIFYING MEMORY

4.1 DISPLAY MODES

A major function of DDT is displaying the contents of memory words, both data and instructions. You can choose whether to display the contents of memory words as symbols or as numeric values. You can also select the radix in which DDT displays numeric values.

DDT displays symbols, labels, and most messages in uppercase.

4.1.1 Default Display Modes

There is no sure way for DDT to distinguish between instruction and data words, or between data words of different formats.

DDT displays memory words in symbolic mode by default. Symbolic mode is described in Table 4-1. DDT tests for the condition on the left, and if the condition is met, displays the word in the format described on the right. DDT performs the tests in descending order.

Table 4-1: Evaluation of Symbolic Display Mode

CONDITION	DDT DISPLAYS	EXAMPLE
Bits 0-18 are all set.	A negative number in the current radix.	-45
The 36-bit value is defined in the user program symbol table.	The symbol.	SYMBL1 HALT
The opcode field is zero.	Halfwords.	345,, -27
The opcode and I, X, and Y fields, or the opcode and A fields match an OPDEF in the user program symbol table.	The OPDEF.	CORE 6,
The opcode matches a definition in DDT's internal hardware instruction table.	The instruction.	MOVE 3,SYMBL
No match.	Halfwords.	3445,, -23

DISPLAYING AND MODIFYING MEMORY

By default, DDT displays numeric values in radix 8. Leading zeros are always suppressed.

4.1.2 Selecting Display Modes

You can select display modes to control:

- o the format in which DDT tries to interpret the contents of memory locations; for example, as instructions, or as floating-point numbers.
- o whether addresses are displayed as symbolic or numeric values.
- o the radix in which numeric values are displayed.

In addition, you can specify these modes on a short-term (temporary mode) or long-term (prevailing mode) basis.

A prevailing display mode remains in effect until you select another prevailing mode, but may be overridden by a temporary mode until you enter a command that restores the prevailing display mode. DDT commands that restore the prevailing display mode are:

- o {expr}<RET> (deposit expr and close location)
- o <ESC>G (start program execution)
- o <ESC>P (proceed from a breakpoint)
- o <ESC>W, <ESC>E, <ESC>N (perform a search)
- o <ESC>Z (zero memory)
- o instr<ESC>X (execute instr)
- o <ESC>Y (execute DDT command file)
- o <ESC>V (watch a location)

The syntax of commands that set the prevailing mode is:

<ESC><ESC>mode

where mode is one of the display modes shown in Table 4-2.

The syntax of commands that set a temporary mode is:

<ESC>mode

where mode is one of the display modes shown in Table 4-2.

The current display mode is the mode (prevailing or temporary) in which DDT will display the next word (unless you enter a command to change the display mode).

DISPLAYING AND MODIFYING MEMORY

DDT has two "masks" that control the action of two of the display modes.

<ESC>3M is a command that addresses a DDT location that contains the output byte size mask. When the current display mode is 0, each bit that is set in the mask indicates the position of a low order bit of a byte in the word being displayed. In this mode, bit 35 is always assumed to be set. For example, if the output byte size mask contains:

```
510410100400 (octal)
```

the byte sizes specified are, from left to right, 1, 2, 3, 4, 5, 6, 7, and 8. When displaying a word in 0 mode that contains 777777,,777777, and the current radix is 8, DDT displays:

```
1,3,7,17,37,77,177,377
```

The default value of the output byte size mask is zero, specifying one 36-bit byte.

You can set the output byte size mask with the command:

```
expr<ESC>3M
```

where expr evaluates to the bit pattern required.

You can also examine and change the output byte size mask with the examine and deposit commands described later in this chapter.

<ESC>2M is a command that addresses a DDT location that contains the maximum symbolic offset. When DDT displays an address in R(elative) mode, it displays the address symbolically, that is, as a symbol, or as a symbol + the numeric offset of the address from that symbol. The maximum symbolic offset (minus 1) determines the maximum offset address that DDT displays symbolically, and defaults to 1000 (octal). DDT displays addresses beyond that offset in A(bsolute) mode. For example, assume that the maximum symbolic offset is 2, and that you are examining subroutine ADDEM in program X.MAC (Fig 2-1), using <LF> to display instructions in sequence. DDT displays:

```
ADDEM/   MOVE 0(6)
ADDEM+1/  ADD 1(6)
addr/    MOVE 2(6)
```

where addr is the absolute address (for example, 14414) of the location.

You can set the maximum symbolic offset with the command:

```
expr<ESC>2M
```

where expr evaluates to the offset required.

You can also examine and change the maximum symbolic offset with the examine and deposit commands described later in this chapter.

DISPLAYING AND MODIFYING MEMORY

DDT display modes and the commands that select them are described in Table 4-2.

Table 4-2: DDT Display Modes

FORMAT MODES	
MODE	EFFECT
C	Display memory word as numbers in the current radix (see Radix Modes).
F	Display memory word as a floating point decimal number.
H	Display memory word as two halfword addresses (see Address Modes) separated by two commas (,,).
O	Display memory word as numeric bytes of sizes that are specified by the <ESC>3M mask.
nØ	Display memory word as n-bit numeric bytes, (with trailing remainder byte, as required).
S	Display memory word in symbolic mode (default).
lS	Search DDT's internal hardware opcode table before searching the user's symbol table, otherwise follow rules for symbolic mode.
nT	Display memory word as ASCII text, using n-bit bytes. n=5: RADIX5Ø n=6: SIXBIT n=7 through 36: Specifies the number of bits per byte. The default is 7-bit ASCII. n=Ø: ASCIZ (Stop ASCIZ typeout by typing any character.)
A	Display addresses as absolute values in the current radix.
R	Display addresses as values relative to symbols (default). DDT displays the offsets in the current radix. The maximum offset is controlled by the value stored in the <ESC>2M mask, and defaults to 1ØØØ (octal).
RADIX MODES	
MODE	EFFECT
nR	Display numeric values in radix n (default=8), where n is a decimal number greater than 1. If n=8, DDT displays the word as octal halfwords, otherwise DDT displays the word as one number.

DISPLAYING AND MODIFYING MEMORY

4.2 DISPLAYING EXPRESSIONS

DDT has three commands you can use to display expressions in different modes. They are:

; (semicolon)
= (equal sign)
_ (underscore)

The syntax of these commands is:

{expr}c

where expr is the expression to display (expr defaults to the current quantity), and c is one of the above commands. These commands are useful for redisplaying the current quantity without affecting the current display mode. Table 4-3 lists the commands to display expressions and their effects.

Table 4-3: Commands to Display Expressions

COMMAND	EFFECT
;	Display the current quantity in the current display mode.
expr;	Display expr in the current display mode.
=	Display the current quantity as a number in the current radix.
expr=	Display expr as a number in the current radix.
-	Display the current quantity in 1\$ mode.
expr_	Display expr in 1\$ mode.

4.3 DISPLAYING BYTE POINTERS

If you set the display mode to 1T, DDT displays the contents of the memory location as a byte pointer. DDT can display one-word local, one-word global, and two-word byte pointers. DDT displays the P and S fields, and the address as determined by the I, X, and Y fields of the byte pointer.

In section zero, DDT displays only one-word byte pointers (local and global).

For example, if the contents of the location at ADDR2 is 100702,,addr, where addr is the value of symbol LABL2, the following illustrates one-word local byte pointer display:

```
addr2/ 100702,,addr <ESC>1T; 10 7 LABL2(2)
```

DISPLAYING AND MODIFYING MEMORY

The following illustrates one-word global byte pointer display, where `addr` is the value of symbol `LABL2`:

```
1,,addr2/ 610002,,LABL2 <ESC>1T; 44&7 2,,LABL2
```

The following illustrates two-word global byte pointer display, where `addr` is the value of symbol `LABL2` (DDT echoes `<BKSP>` as `^H`):

```
1,,addr2/ 440740,,0 <LF>
1,,addr2+1/ 3,,addr <ESC>1T^H
1,,addr2/ 44 7 3,,MAIN. <2>
```

4.4 DISPLAYING AND DEPOSITING IN MEMORY

DDT allows you to display the contents of memory locations and deposit a new value in the open location. In performing these functions, you must understand the concept of the open location, the current location, the location sequence stack, and the current quantity.

The open location is a memory location (or AC) that is "open" for modification by the next command. There is never more than one location open at a time. DDT always closes the open location before opening another.

The location counter contains the address of a word in memory that has been referenced (implicitly or explicitly) by the previous command, and that is the default point of reference for the next command. That word is known as the current location. DDT uses the address of the current location as the default address in most commands. The current location is often, but not always, the open location.

Most DDT commands change the current location to a word specified by an address given (explicitly or by default) in the command. Commands that do not are so indicated.

`."` (period) is a command that returns (but does not display) the address of the current location.

When you first enter DDT, the current location is zero.

The location sequence stack is a "ring" of seventeen words, each containing the address of a prior current location, or of a match found during a search. The present value of the current location is not placed in the ring.

Entries are made to and retrieved from the location sequence stack in a last-in, first-out manner. Most commands that change the location counter by values other than +1 and -1 cause DDT to place the address of the current location (before the change) on the location sequence stack. Addresses of matching locations found during searches are also placed on the location sequence stack. When DDT enters a new value in the next word on the stack, the new value becomes the current location stack entry. This is similar to PUSHing entries on a stack. When the current location stack entry is the last location on the location sequence stack, DDT enters a new value on the stack by "wrapping around" to the beginning of the stack and overwriting the value in the first location on the stack. The first location on the stack then contains the current location stack entry.

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Certain DDT commands change the address of the current location to the current location stack entry, and then change the current location stack entry to the previous entry. This is similar to POPping entries off a stack, and allows you to "return" to locations that have previously been the current location. When the first location on the location sequence stack contains the current location stack entry and DDT changes the address of the current location to the current location stack entry, DDT "wraps around" to the end of the stack, and the value contained in the last word of the stack becomes the current location stack entry (whether or not the stack was previously "full").

The current quantity is a value that is the most recent of:

- o the last 36-bit quantity that DDT displayed (an expression or the contents of a memory location)
- o the last expression that you entered as an argument to a command that deposits to memory

This value is also known as the last value typed. <ESC>Q is a command that returns (but does not display) the current quantity. DDT issues an implicit <ESC>Q to return this value for use as the default argument for some commands.

You can give the current quantity as an argument to a command by entering the command <ESC>Q as the argument.

The command <ESC><ESC>Q returns the current quantity with the right and left halves swapped.

This manual uses the term \$Q to refer to the value that is returned by the command <ESC>Q, and the term \$\$Q to refer to the value that is returned by the command <ESC><ESC>Q.

Some commands calculate the address of the location to be opened from an expression given or defaulted in the command. Other commands use the address of the current location or entries on the location sequence stack.

The general syntax of these commands is:

```
{expr}{<ESC>}c
```

where expr is any legal DDT expression, and c is the command.

NOTE

See Values in DDT Expressions in Chapter 3 for a discussion of long text strings as values in DDT expressions.

DISPLAYING AND MODIFYING MEMORY

Table 4-4 summarizes the commands and their effects. Complete descriptions of the commands follow the table.

Table 4-4: DDT Commands to Display Memory

COMMAND	DISPLAY CONTENTS	MODE OF DISPLAY	OPEN THE LOCATION	CHANGE CURRENT LOCATION	DEPOSIT EXPR
/	Yes	Current	Yes	Yes(1)	No
[Yes	Numeric	Yes	Yes(1)	No
]	Yes	Symbolic	Yes	Yes(1)	No
!	No	Suppress	Yes	Yes(1)	No
\	Yes(2)	Current	Yes	No	Yes(1)
<TAB>	Yes(2)	Current	Yes	Yes	Yes(1)
<RET>	No	Restore	No	No	Yes(1)
<LF>	Yes(2)	Current	Yes	Yes(+1)	Yes(1)
<BKSP> or ^	Yes(2)	Current	Yes	Yes(-1)	Yes(1)
(1) If you enter expr.					
(2) If not suppressed by !.					

4.4.1 Commands That Use the Current Location

The commands <RET>, <LF>, and <BKSP> use the address of the current location to determine the next address of the current location.

These commands do not make entries to the location sequence stack.

{expr}<RET> does the following:

- o deposits expr (if given) in the open location
- o closes the open location
- o resets the current typeout mode to the prevailing typeout mode
- o does not change the address of the current location

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{expr}<LF> does the following:

- o deposits expr (if given) in the open location
- o closes the open location
- o increments the location counter
- o opens the current location
- o displays the open location (unless display has been suppressed by !)

{expr}<BKSP> and {expr}^ do the following:

- o deposit expr (if given) in the open location
- o close the open location
- o decrement the location counter
- o open the current location
- o display the open location (unless display has been suppressed by !)

4.4.2 Commands That Use the Location Sequence Stack

The commands <ESC><RET>, <ESC><LF>, and <ESC><BKSP> use the current location stack entry to determine the next address of the current location.

Repetitions of these commands refer to successively earlier entries on the stack, until you again address the most recent entry.

These commands do not make entries to the location sequence stack.

{expr}<ESC><RET> does the following:

- o deposits expr (if given) in the open location
- o closes the open location
- o changes the value contained in the location counter to the current location stack entry
- o opens the current location
- o starts a new line and displays the address and contents of the open location in the current display mode
- o causes the previous entry on the location sequence stack to become the current location stack entry

NOTE

If display is suppressed as a result of using the ! command, the command {expr}<ESC><RET> restores the current display mode, which can be either a temporary or prevailing display mode.

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{expr}<ESC><LF> does the following:

- o deposits expr (if given) in the open location
- o closes the open location
- o changes the value contained in the location counter to the current location stack entry
- o increments the location counter
- o opens the current location
- o starts a new line and displays the address of the open location
- o displays the contents of the open location (unless display has been suppressed by !)
- o causes the previous entry on the location sequence stack to become the current location stack entry

{expr}<ESC><BKSP> and {expr}<ESC>^ do the following:

- o deposit expr (if given) in the open location
- o close the open location
- o change the value contained in the location counter to the current location stack entry
- o decrement the location counter
- o open the current location
- o display the address of the open location
- o display the contents of the open location (unless display has been suppressed by !)
- o cause the previous entry on the location sequence stack to become the current location stack entry

4.4.3 Commands That Use an Address Within the Command

The commands:

/	(slash)
[(left square bracket)
]	(right square bracket)
!	(exclamation point)
\	(backslash)
<TAB>	

use an expression given in the command (either explicitly or by default) to determine the addresses of the current location and the open location.

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The complete syntax of these commands is:

```
{expr}{<ESC>{<ESC>}}c
```

where `expr` may be an address, ".", a symbol, or any expression that is legal in DDT, and `c` is the command.

When you use the commands `/`, `[`, `]`, `!`, `\`, and `<TAB>`:

- o If you omit `expr`
 - > DDT uses the current quantity as a default.
 - > `<TAB>` enters the address of the current location on the location sequence stack and changes the current location to the address determined from the current quantity.
- o If you enter `expr`, DDT enters the address of the current location on the location sequence stack (except `\`).
- o DDT treats `expr` (whether given or defaulted) as if it were in instruction format and performs the effective address calculation as follows:
 - > If you omit `<ESC>`, DDT does not perform indexing or indirection.
 - > If you include one `<ESC>`, DDT treats `expr` as an IFIW (instruction format indirect word), and uses the I and Y fields of `expr` to perform indexing and indirection when appropriate.
 - > If you use `<ESC><ESC>`, DDT utilizes EFIWs (extended format indirect words), as appropriate, when performing effective address calculations, and can thereby calculate 30-bit addresses.
 - > In section zero, when you include `<ESC><ESC>`, it is treated as one `<ESC>`.

These commands always do the following:

- o close the open location
- o open the location at the address indicated by `expr`
- o change the current quantity to the value displayed (all commands except `!`)

The following is a list that gives a complete description of the effects of each command.

COMMAND

EFFECTS

`/`

- o closes the open location
- o opens the location at the address calculated from the current quantity
- o displays the contents of the open location in the current display mode
- o sets the current quantity to the value displayed

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expr/

- o closes the open location
- o opens the location at the address calculated from expr
- o enters the address of the current location on the location sequence stack
- o changes the current location to the location at the address calculated from expr
- o displays the contents of the open location in the current display mode
- o sets the current quantity to the value displayed

[

- o closes the open location
- o opens the location at the address calculated from the current quantity
- o displays the contents of the open location in numeric mode in the current radix
- o sets the current quantity to the value displayed

expr[

- o closes the open location
- o opens the location at the address calculated from expr
- o enters the address of the current location on the location sequence stack
- o changes the current location to the location at the address calculated from expr
- o displays the contents of the open location in numeric mode in the current radix
- o sets the current display mode to numeric mode in the current radix
- o sets the current quantity to the value displayed

]

- o closes the open location
- o opens the location at the address calculated from the current quantity
- o displays the contents of the open location in symbolic mode
- o sets the current display mode to symbolic mode
- o sets the current quantity to the value displayed

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expr]

- o closes the open location
- o opens the location at the address calculated from expr
- o enters the address of the current location on the location sequence stack
- o changes the current location to the location at the address calculated from expr
- o displays the contents of the open location in symbolic mode
- o sets the current display mode to symbolic mode
- o sets the current quantity to the value displayed

!

- o closes the open location
- o opens the location at the address calculated from the current quantity
- o does not display the contents of the open location
- o suppresses display of the open location by the \, <TAB>, <LF>, and <BKSP> commands (any other display command restores the current display mode)
- o does not change the current quantity

expr!

- o closes the open location
- o opens the location at the address calculated from expr
- o enters the address of the current location on the location sequence stack
- o changes the current location to the location at the address calculated from expr
- o does not display the contents of the open location
- o suppresses display of the open location by the \, <TAB>, <LF>, and <BKSP> commands (any other display command restores the current display mode)
- o does not change the current quantity

\

- o closes the open location
- o opens the location at the address calculated from the current quantity
- o displays the contents of the open location in the current display mode (unless display has been suppressed by !)
- o sets the current quantity to the value displayed

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expr\

- o deposits expr in the open location
- o closes the open location
- o opens the location at the address calculated from expr
- o does not change the address of the current location (and does not enter the address of the current location on the location sequence stack)
- o displays the contents of the open location in the current display mode (unless display has been suppressed by !)
- o sets the current quantity to the value displayed

<TAB>

- o closes the open location
- o opens the location at the address calculated from the current quantity
- o enters the address of the current location on the location sequence stack
- o changes the current location to the location at the address calculated from the current quantity
- o starts a new line and displays the address of the open location (which is also the current location)
- o displays the contents of the open location in the current display mode (unless display has been suppressed by !)
- o sets the current quantity to the value displayed

expr<TAB>

- o deposits expr in the open location
- o closes the open location
- o opens the location at the address calculated from expr
- o enters the address of the current location on the location sequence stack
- o changes the current location to the location at the address calculated from expr
- o starts a new line and displays the address of the open location (which is also the current location)
- o displays the contents of the open location in the current display mode (unless display has been suppressed by !)
- o sets the current quantity to the value displayed

DISPLAYING AND MODIFYING MEMORY

You can treat expr as an IFIW (instruction format indirect word), and use any indexing and indirection specified by expr to compute the effective address of the location to be opened. Use the command form:

```
{expr}<ESC>c
```

where c is /, [,], !, \, or <TAB>.

For example, assume the following conditions as indicated by the display commands:

COMMAND	DISPLAY	EXPLANATION
LABL1/	SYM1	Display contents of LABL1.
LABL1+1/	SYM2	Display contents of LABL1+1.
SYM2/	SYM3	Display contents of SYM2.
2/	1	Display contents of AC 2.
@LABL1(2)/	SYM1	DDT uses Y field only.
@LABL1(2)<ESC>/	SYM3	<ESC> causes indexing and indirection.

Note that DDT does not start a new line unless you enter <TAB>, <RET>, <LF> or <BKSP>, or until the display wraps around the end of the line. DDT also displays three spaces (or a tab, depending on the TTY control mask) before and after its output. Thus, an actual DDT terminal display might be the following (user input is lowercase; <LF> and <TAB> do not appear on the screen, but are shown to indicate where you pressed the corresponding keys):

```
2/ 1 labl1/ SYM1 <LF>
LABL1+1/ SYM2 <TAB>
SYM2/ SYM3 sym4/ MOVE 1,@LABL1(2) <ESC><TAB>
SYM2/ SYM3
```

You can treat expr as an EFIW (extended format indirect word) and use any indexing and indirection specified by expr to compute the (global) effective address of the location to be opened. Use the command form:

```
{expr}<ESC><ESC>c
```

where c is /, [,], !, \, or <TAB>.

4.5 DISPLAYING ASCIZ STRINGS

You can display memory as an ASCIZ string. The command

```
addr<ESC>ØT
```

where addr defaults to the open location (if there is one, otherwise addr defaults to the current location), displays memory, beginning with addr, as an ASCIZ string. The display stops when DDT finds a zero byte, or when you type in any character, which DDT displays, but otherwise ignores. The current location remains unchanged.

DISPLAYING AND MODIFYING MEMORY

4.6 ZEROING MEMORY

To deposit the same value in each of a string of memory words (useful for initializing memory to zero), enter:

```
addr1<addr2>{expr}<ESC>Z
```

where `expr` is any legal DDT expression, `addr1` is the first word to receive `expr`, and `addr2` is the last. Follow `addr1` with a left angle bracket (<) and `addr2` with a right angle bracket (>). Both `addr1` and `addr2` are required. If you omit `expr`, it defaults to zero. Prior to execution, DDT enters the address of the current location on the location sequence stack and closes the open location. When DDT has completed execution of the command, the current location is the word at `addr2 + 1`. There is no open location. This command restores the prevailing display mode.

If you enter:

```
?
```

while DDT is executing the <ESC>Z command, DDT displays:

```
Depositing: addr/ value
```

where addr is the location where DDT will make the next deposit, and value is the contents of addr before the deposit.

If you enter any other character, DDT stops executing the <ESC>Z command, and waits for your next command. The character that you enter to terminate the <ESC>Z command is otherwise ignored.

4.7 AUTOMATIC WRITE-ENABLE

If you attempt to change a word that is write-protected, DDT removes the protection, makes the change, and then reinvokes the protection.

To prevent DDT from changing write-protected memory, enter:

```
<ESC><ESC>{0}W
```

If you attempt to modify write-protected memory while automatic write-enable is turned off, DDT returns the message:

```
?NOT WRITABLE
```

To allow DDT to change write-protected memory, enter:

```
<ESC>{0}W
```

This is the default condition.

The zero in the above commands is optional and has no effect on the operation of the commands.

DISPLAYING AND MODIFYING MEMORY

4.8 AUTOMATIC PAGE CREATION

If you attempt to deposit a value in a word within a nonexistent page, DDT sounds your terminal buzzer or bell and displays a question mark (?).

To allow DDT to create a page when you attempt to deposit a word within a nonexistent page, enter:

```
<ESC>lw
```

If DDT tries to create the page and fails, DDT displays:

```
?CAN'T CREATE PAGE
```

To prevent DDT from creating a page when you attempt to deposit a value within a nonexistent page, enter:

```
<ESC><ESC>lw
```

This is the default condition.

4.9 DISPLAYING PAGE ACCESSIBILITY INFORMATION

You can get information about the access requirements of the pages and sections in the program you are debugging, using the \$L and \$\$L commands. The complete format for this command is:

```
{{arg1<}arg2}}<ESC><ESC>L
```

where arg1 and arg2 are sections numbers. Using one <ESC> causes DDT to display access information about the section and about individual pages. Using <ESC> twice causes DDT to display access information only about the section(s). If you include both arg1 and arg2, DDT displays the information for all sections that your program and DDT are using, in the range arg1 to arg2, inclusive. If you include only arg2, DDT displays access information for that section only. If you omit both arguments, DDT displays access information for all sections that your program and DDT are using.

The page and section accessibility bits and their meanings are:

Read	Page can be read.
Write	Page can be written.
AA	Page access is allowed.
Sharable	Page can be shared.
Hiseq	Page is part of high segment.
Zero	Page is allocated but zero.
Spying	Page is spying on someone.
Cannot page	Page cannot be paged out.
Paged out	Page has been paged out.
Locked	Page is locked in core.
Not cached	Page is not cached.

DISPLAYING AND MODIFYING MEMORY

For example, the command <ESC>L might produce the following display:

```
Section 0
000          Read, Write, AA, Cannot page
001-030      Read, Write, AA
577          Read, Write, AA
600-656      Read, AA, Sharable, Hiseq
```

```
Section 1 indirect to section 0
000          Read, Write, AA, Cannot page
001-030      Read, Write, AA
577          Read, Write, AA
600-656      Read, AA, Sharable, Hiseq
```

```
Section 3
000-777      Read, Write, AA
```

```
Section 4
000-354      Read, Write, AA
```

And the command <ESC><ESC>L might product a display like the following:

```
Section 0
Section 1 indirect to section 0
Section 3
Section 4
```

4.10 WATCHING A MEMORY LOCATION

If you wish to have DDT monitor or "watch" a memory location while your program is running, and display the location whenever its contents change, enter:

```
addr<ESC>V
```

where addr is the address of the location to be watched, and defaults to the current location. When you enter the command, DDT starts a new line and displays:

```
addr/ value
```

where addr is the address of the location being watched, and value is the contents of the location. This command also restores the prevailing display mode.

DDT checks addr every "jiffy" (about 20 milliseconds), and displays the address and contents of addr whenever those contents change. (Executive mode EDDT watches addr continuously.)

If you enter a question mark (?) while DDT is watching, DDT displays:

```
Watching: addr/ value
```

where addr is the address of the location being watched, and value is the contents of addr.

To terminate the watch, enter any other character. DDT stops monitoring the word, starts a new display line, echoes the character you enter, starts another line, and waits for more input. The character that you enter to terminate the watch is otherwise ignored.

DISPLAYING AND MODIFYING MEMORY

Because any input character terminates the watch, you cannot continue execution and watch your own user program. The <ESC>V command is useful to watch activity in a separate process (such as the running monitor or other job, for which you must be using EDDT or FILDDT). The page that contains the word you wish to watch must be mapped into your own process (the one that contains DDT and your program).

4.11 TTY CONTROL MASK

You can control certain aspects of DDT's display by setting DDT's TTY control mask. The command <ESC>1M returns a value that is the address of the DDT location that contains this mask. Table 4-5 summarizes the features controlled by the bits in the TTY control mask.

Table 4-5: TTY Control Mask

BIT	VALUE	EXPLANATION
15	0	Display the commands (and results) from the file executed by the <ESC>Y command (default).
	1	Do not display the commands (or results) from the file executed by the <ESC>Y command.
16	0	When interrupting program execution at a breakpoint, display the address and contents of the breakpoint (default).
	1	When interrupting program execution at a breakpoint, display only the address of the breakpoint.
17	0	Display 3 spaces when spacing DDT output (1).
	1	Display DDT output fields at tab stops (1).
34	0	The terminal does not have a tab mechanism (2).
	1	The terminal has a tab mechanism (2).
35	0	Echo deleted characters (3).
	1	Backspace over deleted characters (3).

(1) If bit 17 is reset (default), DDT displays 3 spaces between output fields (such as between the address of a location and the contents of the location), and at the end of display lines. If bit 17 is set, DDT lines up the output fields in columns beginning at tab stops (see bit 34).

Figure 4-1 illustrates the two different modes.

(2) If bit 34 is set, DDT displays a tab character (<CTRL/I>) between fields. If bit 34 is reset, DDT displays enough spaces to start the field at the next tab stop. When starting up, DDT checks whether your terminal can handle TAB characters (<CTRL/I>), and sets this bit accordingly.

(3) When starting up, DDT checks whether your terminal can backspace to delete characters, and sets this bit accordingly.

DISPLAYING AND MODIFYING MEMORY

To change the settings of the TTY control mask, use the command:

```
expr<ESC>1M
```

where expr evaluates to the required bit pattern.

You can also open the location addressed by <ESC>1M with one of the DDT display commands, and deposit an expression that contains the new bit settings.

Figure 4-1 is an illustration of the effects of bit 17 in the TTY control mask. The code being examined is the first few lines of X.MAC, listed in Figure 2-1. The example is not a complete debugging session; only enough is shown to illustrate the effects of bit 17 of the TTY control mask. The numbers at the left of the DDT display lines are to assist you in following the commentary that follows the display. User input is in lowercase.

Figure 4-1: DDT Session Showing Columnar Output

SCREEN DISPLAY

```
1.      DDT
2.      start/  MOVE P,PWORD  x$:  .$b  $g
3.      $1B>>START/  MOVE P,PWORD  $x
4.      P/      -10,,STACK  PWORD/  -10,,STACK
5.      START+1/  MOVEI IDX,TABLE1  $x
6.      IDX/     TABLE1  TABLE1  $1m/  2  1,,2
7.      start$g
8.      $1B>>START/  MOVE P,PWORD  $x
9.      P/      -10,,STACK  PWORD/  -10,,STACK
10.     START+1/  MOVEI IDX,TABLE1  $x
11.     IDX/     TABLE1  TABLE1
```

COMMENTARY

Line 1:

- o DDT is loaded and waiting for a command.

Line 2:

- o Enter start/ to examine location start.
- o Enter x<ESC>: to open the symbol table for module X.
- o Enter .<ESC>b to set breakpoint at location START.
- o Enter <ESC>g to begin execution.

Line 3:

- o DDT displays breakpoint information.
- o Enter <ESC>x to execute the next instruction.

Line 4:

- o DDT displays results of executing the instruction.

DISPLAYING AND MODIFYING MEMORY

Line 5:

- o DDT displays the next instruction.
- o Enter <ESC>x to execute the instruction.

Line 6:

- o DDT displays the results of executing the instruction.
- o Enter <ESC>lm/ to display and open the TTY control mask.
- o DDT displays the mask. Bit 34 is set.
- o Enter 1,,2<RET> to set bits 17 and 34.

Line 7:

- o Enter start<ESC>g to restart the program.

Line 8:

- o DDT displays the breakpoint information.
- o Enter <ESC>x to execute the instruction.

Line 9:

- o DDT displays the results of executing the instruction.

Line 10:

- o DDT displays the next instruction.
- o Enter <ESC>x to execute the next instruction.

Line 11:

- o DDT displays the results of executing the instruction.

CHAPTER 5

CONTROLLING PROGRAM EXECUTION

5.1 BEGINNING EXECUTION

To begin execution of your program, enter:

```
<ESC>G
```

Your program will run, beginning at its start address. If you have not set any breakpoints, your program runs to completion, or until it makes a fatal error. At TOPS-10 command level, you can then use the DDT command to reenter DDT and examine your program.

You can start or continue program execution at any address with the command:

```
addr<ESC>G
```

5.2 USING BREAKPOINTS

A breakpoint is a program location that has been altered such that if your program PC reaches the address of the breakpoint, your program transfers control to DDT.

When you set a breakpoint with DDT, DDT stores the address of the breakpoint in an internal table. When you command DDT to begin or continue program execution, DDT stores the instructions from all breakpoints in the table, and replaces them with JSRs into a DDT entry table.

While program execution is suspended at a breakpoint, you can examine and modify memory, remove breakpoints, insert new breakpoints, execute individual instructions, and continue program execution.

During this time, the command "<ESC>." returns the value that is the address of the next instruction to be executed. The command "<ESC><ESC>." returns a value that is the previous value returned by "<ESC>.". When you first receive control at the breakpoint, "<ESC>." returns the address of the breakpoint and "<ESC><ESC>." returns zero. Before you start execution with <ESC>G, "<ESC>." and "<ESC><ESC>." are illegal commands (if you try to execute them, DDT sounds the terminal buzzer or bell and displays a question mark).

NOTE

This manual uses the term "\$." to represent the value returned by the command "<ESC>.", and the term "\$\$." to represent the value returned by the command "<ESC><ESC>.".

CONTROLLING PROGRAM EXECUTION

You can set up to 12 breakpoints at a time (this is a DDT assembly parameter) in your program. These breakpoints are numbered 1 through 12. There is also one breakpoint (the unsolicited breakpoint, numbered zero) that can be used by your MACRO program to "call" DDT.

Each breakpoint has several internal DDT locations associated with it, which contain information to control DDT action with respect to the breakpoint. You can examine and modify these DDT locations with the same DDT commands that you use to examine and modify locations in your user program. <ESC>nB is a command that returns the value that is the address of the first DDT word associated with breakpoint n. The symbol \$nB is used here to represent that address.

Table 5-1 contains a list of the breakpoint locations of interest to the user, and their contents.

Table 5-1: Breakpoint Locations of Interest

LOCATION	CONTENTS
\$nB	Address of breakpoint n.
\$nB+1	Instruction for conditional breakpoint n.
\$nB+2	Proceed count for conditional breakpoint n.
\$nB+3	Address of a location to be opened and displayed when the breakpoint is reached.
\$nB+4	Address of an ASCIZ DDT command string to be executed when the breakpoint is reached.

When your user-program PC reaches a breakpoint, your program executes the JSR into DDT. When this occurs, DDT does the following:

- o saves your user-program context
- o replaces the JSR instructions at all breakpoints with the original program instructions
- o displays the breakpoint number, breakpoint address, and the contents of the breakpoint (depending on bit 16 of the TTY control mask)
- o sets "\$." to the breakpoint address
- o sets "\$\$." to zero
- o enters the address of the current location (set before you started the program or proceeded from a breakpoint) on the location sequence stack
- o changes the current location to the breakpoint
- o waits for you to give a DDT command

CONTROLLING PROGRAM EXECUTION

When you command DDT to restart or continue program execution, DDT does the following:

- o saves the program instructions from all breakpoints
- o replaces the program instructions at all breakpoints with JSR instructions to DDT
- o if you have not executed the instruction at the breakpoint with <ESC>X, DDT simulates execution of the instruction at the breakpoint
- o restores your user-program context
- o DDT performs a JRSTF (if in section zero, otherwise XJRSTF) to the next instruction to be executed

5.2.1 Setting Breakpoints

To set a breakpoint, enter:

```
addr<ESC>{n}B
```

where addr is the address where you want to suspend execution (addr can be ".", the command that returns the address of the current location), and n is the number of the breakpoint (and defaults to the lowest unused breakpoint number).

If you do not specify n, it defaults to the lowest available (unset) breakpoint. If you have already set twelve breakpoints, DDT displays "?" and sounds the terminal buzzer or bell.

If you specify n, it must be greater than zero and less than 13. DDT restores the original contents of any (previously set) breakpoint designated as breakpoint n before setting new breakpoint n.

You cannot set more than one breakpoint at the same address. DDT simply sets the same breakpoint again, even if you explicitly specify a breakpoint number the second time.

You cannot set a breakpoint at AC zero.

Assume the following conditions:

- o location LABL1+3 contains the instruction MOVE 1,LABL2
- o breakpoint 2 is set at LABL1+3

If your program reaches LABL1+3 it executes the JSR to DDT, and DDT does the following:

- o saves your user-program context
- o restores the original program instructions to the breakpoints
- o sets "\$." to LABL1+3
- o sets "\$\$." to zero
- o enters the address of the current location on the location sequence stack

CONTROLLING PROGRAM EXECUTION

- o changes the current location to LABL1+3 (the breakpoint)
- o opens location LABL1+3
- o displays: \$2B>>LABL1+3/ MOVE 1,LABL2

To set a breakpoint and have DDT display an additional location when your program reaches the breakpoint, enter:

```
addr1<addr2<ESC>{n}B
```

where addr1 is the location to be displayed, and addr2 is the location of the breakpoint. Follow addr1 with a left angle bracket (<).

Assume the following conditions:

- o location LABL1+3 contains the instruction MOVE 1,LABL2
- o location LABL3 contains value SYMBL1
- o breakpoint 2 was set by the command:

```
LABL3<LABL1+3<ESC>B
```

If your program reaches LABL1+3 it executes the JSR to DDT, and DDT does the following:

- o saves your user-program context
- o restores the original program instructions to the breakpoints
- o sets "\$." to LABL1+3
- o sets "\$\$." to zero
- o enters the address of the current location on the location sequence stack
- o changes the current location to LABL1+3 (the breakpoint)
- o enters the address of the current location (the breakpoint) on the location sequence stack
- o changes the current location to LABL3
- o opens location LABL3
- o displays: \$2B>>LABL1+3/ MOVE 1,LABL2 LABL3/ SYMBL1

Note that, because DDT placed the breakpoint address on the location sequence stack, you can enter <ESC><RET> to change the current location back to the breakpoint.

When invoked at a breakpoint, DDT can also execute a string of DDT commands that is stored as an ASCIZ string. To invoke this function, enter:

```
{addr1<}addr2>addr3<ESC>{n}B
```

where addr1 is an optional location to be displayed, addr2 is the address of the ASCIZ string containing the DDT commands, and addr3 is the address of the breakpoint. Follow addr1 with a left angle bracket (<) and addr2 with a right angle bracket (>).

CONTROLLING PROGRAM EXECUTION

This command is legal only if feature-test FTYANK was turned on when DDT was assembled.

If your program reaches `addr3` it executes the JSR to DDT, and DDT does the following:

- o saves your user-program context
- o restores the original program instructions to the breakpoints
- o sets "\$." to `addr3`
- o sets "\$\$." to zero
- o enters the address of the current location on the location sequence stack
- o changes the current location to `addr3` (the breakpoint)
- o displays the breakpoint number
- o displays the address and contents of the location at `addr3`
- o if you give `addr1` in the command, DDT does the following:
 - > enters `addr3` on the location sequence stack
 - > changes the current location to `addr1`
 - > opens the location at `addr1`
 - > displays the contents of the location at `addr1`
- o executes the DDT commands stored as an ASCIZ string at `addr2`

If you give `addr1` in the command, DDT places the breakpoint address on the location sequence stack, and you can enter `<ESC><RET>` to change the current location back to the breakpoint.

To display the address of any breakpoint, enter:

```
<ESC>nB/
```

where `n` is the address of the breakpoint. DDT displays the address of breakpoint `n`, and you can use the examine commands to open and display the instruction at breakpoint `n`. If breakpoint `n` is not set, DDT displays zero.

To remove breakpoint `n`, enter:

```
Ø<ESC>nB
```

To remove all breakpoints, enter:

```
<ESC>B
```

CONTROLLING PROGRAM EXECUTION

5.2.2 Proceeding from Breakpoints

After your program has reached a breakpoint, you can continue execution at "\$." by entering:

```
<ESC>P
```

DDT saves the program instructions from all breakpoints, replaces the program instructions with JSRs to DDT, restores your user-program context, and if you have not executed any program instructions with the <ESC>X command, simulates execution of the instruction at the breakpoint. DDT then executes a JRSTF (in section zero, otherwise DDT executes an XJRSTF) to the next instruction to be executed.

You can cause the program to start execution at a different location with the {addr}<ESC>G command, where addr defaults to the program's start address.

Once your program has reached a breakpoint and DDT has interrupted execution, you can cause DDT to continue execution but NOT stop at that breakpoint until your program has reached that breakpoint a specified number of times. To do this, enter:

```
expr<ESC>P
```

where expr is the proceed count. DDT places expr at location \$nB+2, where n is the number of the breakpoint at which your program has stopped. DDT resumes execution of your program. Each time your program reaches breakpoint n, DDT decrements the proceed count stored at \$nB+2. Your program continues execution until:

- o it reaches a different breakpoint
- o it terminates normally
- o it commits a fatal error
- o the proceed count reaches zero

Each breakpoint has an associated automatic proceed flag. If this flag is set and the program reaches the breakpoint, DDT decrements the proceed count at \$nB+2 (where n is the number of the breakpoint) and displays the breakpoint information if the proceed count is less than one. DDT then automatically continues program execution.

The <ESC>P command resets (clears) the automatic proceed flag associated with the breakpoint at which DDT has suspended program execution.

To set a breakpoint and set the associated automatic proceed flag, enter:

```
{addr1<}addr2<ESC><ESC>{n}B
```

where addr2 is the address of the breakpoint and may be "\$.", addr1 is an (optional) additional location to be displayed, and n is optional and defaults to the lowest unused breakpoint.

CONTROLLING PROGRAM EXECUTION

Each time your program reaches breakpoint *n*, DDT decrements the associated proceed count, and if the result is less than one, displays:

```
$nB>>addr2/ instr
```

where *n* is the breakpoint number, *addr2* is the address of the breakpoint, and *instr* is the contents of the word at *addr2*.

If you entered *addr1* when you gave the command, DDT displays:

```
$nB>>addr2/ instr addr1/ contents
```

where *n* is the breakpoint number, *addr2* is the address of the breakpoint, *instr* is the contents of the word at *addr2*, *addr1* is the additional location to be displayed, and contents is the contents of the word at *addr1*.

DDT then automatically continues program execution until:

- o your program reaches a different breakpoint
- o your program terminates normally
- o your program commits a fatal error
- o you enter any character while your program is at breakpoint *n*

You can interrupt the automatic proceed function if you enter a character while your program is at breakpoint *n*. DDT then resets the automatic proceed flag and suspends program execution at the breakpoint. DDT echoes the character that you entered, which is otherwise ignored.

To have DDT execute a DDT command stored as an ASCII string when you interrupt the automatic proceed cycle, enter:

```
{addr1}<addr2>addr3<ESC><ESC>{n}B
```

where *addr1* is an optional location to be displayed, *addr2* is the address of the ASCII string containing the DDT commands, and *addr3* is the address of the breakpoint. Follow *addr1* with a left angle bracket (<) and *addr2* with a right angle bracket (>).

If your program reaches breakpoint *n*, DDT displays the requested information and automatically continues program execution. DDT executes the ASCII DDT command string stored at *addr2* only when you interrupt the automatic proceed cycle by entering any character.

If feature-test FTYANK was not turned on when DDT was assembled, DDT does not execute the command string stored at *addr2*.

To proceed from a breakpoint and set the associated automatic proceed flag, give the command:

```
{expr}<ESC><ESC>P
```

where *expr* is the proceed count. DDT stores the proceed count at *\$nB+2*.

CONTROLLING PROGRAM EXECUTION

5.2.3 Conditional Breakpoints

To cause DDT to interrupt program execution at a breakpoint only if a specific condition is satisfied, you must store a single test instruction or a call to a test routine in DDT's breakpoint table. You can use a test routine in your program, or one that you enter in DDT's patching area. See Chapter 8 (Inserting Patches with DDT) for more information about the patching area. To enter the test instruction (or the call to the test routine), open the DDT location addressed by the command <ESC>nB+1 by entering:

```
<ESC>nB+1/
```

where n is the number of the breakpoint. You must enter n, or DDT interprets the command as <ESC>B, and removes all breakpoints. Deposit the test instruction or the call to the test subroutine. If your program reaches breakpoint n, DDT executes the instruction at \$nB+1. DDT then proceeds as follows:

- o If the instruction does not cause a program counter skip, DDT decrements the proceed count at \$nB+2. If the result is zero or less, DDT interrupts execution at breakpoint n.
- o If a program counter skip of 1 does occur, DDT interrupts execution at breakpoint n.
- o If the conditional instruction is a call to a subroutine that returns by skipping over two or more instructions, DDT does not interrupt program execution.

If DDT interrupts execution because the test instruction resulted in a program counter skip, DDT displays only one angle bracket after the breakpoint identification, as:

```
$3B>LABL1/ MOVE 1,LABL2
```

5.2.4 The "Unsolicited" Breakpoint

You can cause your MACRO program to "call" DDT by inserting the following instruction in your program:

```
JSR $ØBPT##
```

The two pound-signs (##) appended to \$ØBPT in your MACRO program declare the symbol as EXTERNAL.

NOTE

"\$" represents the dollar sign character, which is part of the symbol, and is not the DDT echo of the ESCAPE key.

CONTROLLING PROGRAM EXECUTION

You must load DDT.REL with your program or you will get a LINK error (?LNKUGS undefined global symbol) when you load your program. Load DDT.REL with your program as follows (your input is in lowercase; the last line indicates that DDT is loaded and ready to accept your commands):

```
.r link
*/debug filnam/go
DDT
```

where filnam is the name of your MACRO-10 program. You can start your program running with the <ESC>G command. If your program executes the JSR instruction, DDT interrupts program execution and displays:

```
$0B>>addr+1/ instr
```

where addr+1 is the first location after the JSR \$0BPT instruction, and instr is the contents of that location.

The following sequence of instructions provides another way to have your MACRO program call DDT:

```
CALDDT: SKIPN .JBBPT
          JRST [OUTSTR ASCIZ\%DDT not loaded\
              POPJ P,]
          JSR  @.JBBPT
          POPJ P,
```

If DDT is loaded in memory (as indicated by a nonzero value in JOBDAT location .JBBPT), you can interrupt your program and transfer control to DDT by entering:

```
<CTRL/D>
```

You must have first used the TOPS-10 command SET DDT BREAKPOINT ON (see the TOPS-10 Commands Reference Manual). The monitor interrupts your program and transfers control to DDT, which displays:

```
$0B>>CALDDT+3/ POPJ P,
```

You can use the sequence of TOPS-10 commands shown in the following terminal display to get DDT loaded into memory with your program (the commands you enter are in lowercase):

```
.get filnam
.ddt
DDT
<ESC>g
```

If you did not load and save DDT.REL with your program, you will get VMDDT instead of DDT.

5.3 EXECUTING EXPLICIT INSTRUCTIONS

To execute a specific instruction, enter the instruction followed by <ESC>X:

```
instr<ESC>X
```

For example:

```
MOVE 1,@LABEL1(3)<ESC>X
```

CONTROLLING PROGRAM EXECUTION

After executing the instruction, DDT starts a new line and displays:

- o <> if in-line execution of instr would result in skipping no instructions.
- o <SKIP> if in-line execution of instr would result in skipping 1 instruction.
- o <SKIP 2> if in-line execution of instr would result in skipping 2 instructions.
- o <SKIP 3> if in-line execution of instr would result in skipping 3 instructions.

NOTE

"In-line execution" means execution of the instruction as part of normal program flow. The execution of instructions with this command has no effect on your user-program PC.

This command restores the prevailing display mode.

5.4 SINGLE-STEPPING INSTRUCTIONS

After your program has transferred control to DDT from a breakpoint, you can execute program instructions one at a time. This is called "single-stepping."

"<ESC>." is a command that returns the address of the next instruction to be executed.

To execute the instruction whose address is returned by "<ESC>.", enter:

```
<ESC>X
```

For example, breakpoint 3 is set at LABL1+3. If your program PC reaches LABL1+3, control passes to DDT, which displays:

```
$3B>>LABL1+3/ ADD 1,LABL2(2)
```

Examining the environment, you learn the following:

- o AC 1 contains 1
- o AC 2 contains 3
- o LABL1+4 contains MOVEM 1,@LABL2(3)
- o LABL2+3 contains SYM3

as shown by the following terminal display (DDT does not display <LF> or <ESC>):

```
$3B>>LABL1+3/ ADD 1,LABL2(2) <ESC>\ SYM3 <LF>  
LABL1+4/ MOVEM 1,@LABL2(3) 1/ 1 <LF>  
2/ 3
```

CONTROLLING PROGRAM EXECUTION

If you now enter the command <ESC>X, DDT does the following:

- o changes "\$\$. " to LABL1+3
- o executes the instruction at LABL1+3
- o changes "\$. " to LABL1+4
- o changes the current location to LABL1+4
- o opens LABL1+4
- o displays:

```
      1/  SYM3+1  LABL2+3/  SYM3
LABL1+4/  MOVEM 1,@LABL2(3)
```

If single-stepping an instruction results in a value of (\$. minus \$\$.) not equal to 1, DDT also begins a new line and displays:

- o <SKIP> if (\$. minus \$\$.) = 2
- o <SKIP 2> if (\$. minus \$\$.) = 3
- o <SKIP 3> if (\$. minus \$\$.) = 4
- o <JUMP> if (\$. minus \$\$.) is greater than 4 or less than 1

before displaying the address and contents of the next instruction to be executed. For example, the following shows a typical terminal display where you enter <ESC>X to single-step the first instruction at a breakpoint (DDT echoes <ESC> as \$):

```
$4B>>LABL1+5/  AOSN 3  /  0  <ESC>x
      3/  1

<SKIP>
LABL1+7/  MOVEM 1,LABL2
```

5.5 EXECUTING SUBROUTINES AND RANGES OF INSTRUCTIONS

To execute a series of n instructions beginning with the instruction whose address is returned by the command "<ESC>.", enter:

```
n<ESC>X
```

where n is the number of instructions to execute.

DDT then does the following for each instruction:

- o starts a new display line
- o executes the instruction
- o displays the address of any register or memory location referenced by the execution of the instruction, and the contents of those locations after execution of the instruction
- o changes the current location to the next instruction to be executed

CONTROLLING PROGRAM EXECUTION

- o opens the current location
- o displays the address and contents of the next instruction to be executed
- o changes "\$." to the address of the next instruction to be executed
- o changes "\$\$." to the address of the instruction just executed

To suppress typeout of all but the last instruction executed, use the command:

```
n<ESC><ESC>X
```

where n is the number of instructions to execute.

To continue program execution until the PC (program counter) enters a range of instructions, enter:

```
{addr1<}{addr2>}<ESC><ESC>X
```

where addr1 is the lower end of the range, and addr2 is the upper end. Addr1 defaults to 1 + "\$." and addr2 defaults to addr1 + 3. Follow addr1 with a left angle bracket (<) and addr2 with a right angle bracket (>).

This command also indicates skips and jumps.

This command is useful for executing a loop or a subroutine call quickly and without typeout.

For example, breakpoint 3 is at location LABL1.

```
$3B>>LABL1/  PUSHJ 17,SUBRTN  <ESC><ESC>X  ;Enter <ESC><ESC>X  
<SKIP>                                ;SUBRTN returns + 2  
LABL1+2/  ADD 1,2
```

If you enter a question mark (?) while DDT is executing an <ESC><ESC>X command, DDT displays:

```
Executing: addr/  instr
```

where addr is the address of the next instruction to be executed, and instr is the instruction.

To terminate the execution of the series of instructions, enter any character other than ? (question mark). DDT does the following:

- o echoes the character
- o displays <SKIP>, <SKIP 2>, <SKIP 3>, or <JUMP>, as appropriate
- o starts a new display line
- o changes the current location to the address of the next instruction to be executed
- o displays the address and contents of the current location
- o opens the current location
- o waits for your next command

CONTROLLING PROGRAM EXECUTION

5.5.1 Single-Stepping "Dangerous" Instructions

DDT classifies the following as "dangerous" instructions:

- o instructions that can modify memory
- o instructions that can cause an arithmetic trap
- o instructions that can cause a stack overflow
- o a monitor call or I/O instruction

Before single-stepping one of these instructions, DDT saves and replaces the original instructions at the breakpoints with JSRs to DDT, and restores the full user-program context (including interrupt system and terminal characteristics) before executing the instruction. After executing the instruction, DDT replaces the JSRs at the breakpoints with the original program instructions, and saves the full user-program context.

DDT does not check whether the instruction actually results in one of these conditions, only whether the opcode is in the class of instructions that can cause these effects. This can make executing subroutines and ranges of instructions under DDT control extremely time-consuming.

To execute a subroutine or series of instructions without checking for dangerous instructions, use the command:

```
{addr1<}{addr2>}<ESC><ESC>1X
```

where addr1 is the lower end of the range, and addr2 is the upper end. Addr1 defaults to 1 + "\$." and addr2 defaults to 3 + addr1. Follow addr1 with a left angle bracket (<), and addr2 with a right angle bracket (>). This command executes much faster than <ESC><ESC>X, but if the execution of an instruction causes a software interrupt, the error and trap handling mechanism may not function correctly. In addition, program instructions that change or rely on terminal or job characteristics that are also used by DDT can cause unpredictable results.

5.6 USER-PROGRAM CONTEXT

When DDT interrupts your program's execution at a breakpoint, and after it has executed a dangerous instruction during an <ESC>X or <ESC><ESC>X command, it saves the user-program context. The command <ESC>nI, where 0<=n<=10 (octal), returns the address of the word that contains the information for "function" n. You can use this address to display and modify these values. Most of these values are useful only in executive mode. DDT displays the address of the word containing the information for function n as:

```
$I+n
```

where 1<=n<=10 (octal). If n = 0, DDT displays only \$I.

CONTROLLING PROGRAM EXECUTION

Table 5-2 lists the functions.

Table 5-2: User-Program Context Values

FUNCTION	VALUE
0	Executive mode CONI PI.
1	Executive mode PI channels turned off.
2	Executive mode CONI APR.
3	User PC flags.
4	User PC address.
5	EPT page address.
6	UPT page address.
7	CST base virtual address.
10	SPT base virtual address.

DDT restores the user-program context whenever you execute <ESC>G, <ESC>P, and when you execute <ESC>X, or <ESC><ESC>X of dangerous instructions.

Functions 5 through 10 (octal) affect DDT's interpretation of your program's virtual address space. You can alter DDT's interpretation of your program's virtual address space with the physical and virtual addressing (<ESC>nU) commands described in Chapter 11 (Physical and Virtual Addressing Commands). However, any alterations that you make do not become part of your user-program context, and do not affect TOPS-10's interpretation of your program's virtual address space.

DDT also saves and restores the user-program ACs as part of the user-program context. DDT stores the contents of the ACs in an internal "register" block. Any references you make to addresses 0-17 refer to the relative locations in DDT's internal register block. These actions are totally transparent to you.

CHAPTER 6

SEARCHING FOR DATA PATTERNS IN DDT

With DDT you can search for memory locations that contain a specific value, and conversely, for words that do not contain a specific value. You can also set a mask to indicate to DDT that only specified bits are to be considered when performing the search. In addition, you can search for words that reference a specific address. You can specify a range within which to perform the search, or default the range to all of your program's address space. In either case, DDT compares the contents of each location within the range with the specified value.

To search for words that match a specific value, enter:

```
{addr1<}{addr2>}expr<ESC>W
```

where `expr` is the value for which DDT is to search, and `addr1` and `addr2` delimit the range in which the search is to be conducted. Follow `addr1` with a left angle bracket (<) and `addr2` with a right angle bracket (>). `addr1` defaults to zero and `addr2` defaults to 77777 in the current section. `Expr` can be any legal DDT expression.

DDT does the following:

- o compares each location (after ANDing it with the search mask) within the search range with the 36-bit value resulting from evaluating `expr`
- o starts the search by comparing the contents of `addr1` with `expr`
- o stops the search after comparing the contents of `addr2` with `expr`
- o displays (on a new line) the address and contents of each location that matches `expr`
- o enters the address of each matching location on the location sequence stack
- o sets the current location to `addr2`
- o displays a blank line to indicate the search is over
- o restores the prevailing display mode

NOTE

If DDT finds more matching locations than there are words on the location sequence stack, the earlier entries are overwritten.

SEARCHING FOR DATA PATTERNS IN DDT

NOTE

When you use the DDT search functions while running FILDDT, addr2 defaults to 777777 (in the current section) unless:

- o the target is the running monitor or other running job and you are using physical addressing
- o the target is an .EXE file and you are using normal virtual addressing
- o the target is a disk structure or data file

In these cases, addr2 defaults to the last word of the target. See Chapter 9 (FILDDT), and Chapter 11 (Physical and Virtual Addressing Commands), for more information.

To search for words that do NOT match a specified value, enter:

```
{addr1<}{addr2>}expr<ESC>N
```

where expr is the value which is not to be matched, and addr1 and addr2 delimit the range within which DDT is to search. Follow addr1 with a left angle bracket (<) and addr2 with a right angle bracket (>). Addr1 defaults to zero and addr2 defaults to 777777 in the current section. (If you are using FILDDT, see the note following the description of the <ESC>W search command.) Expr is any legal DDT expression.

DDT functions as for the <ESC>W command, except:

- o DDT searches for and displays the address and contents of any word within the address range that does NOT match the 36-bit value resulting from evaluating expr.
- o DDT enters the locations of non-matching words on the location sequence stack.

To search for references to an address, enter:

```
{addr1<}{addr2>}expr<ESC>E
```

where addr1 and addr2 delimit the range of the search, and expr contains the address for which DDT is to search. Follow addr1 with a left angle bracket (<) and addr2 with a right angle bracket (>). Addr1 defaults to zero and addr2 defaults to 777777 in the current section. Expr is any legal DDT expression.

DDT performs an IFIW effective address calculation on the expression contained in each word within the range, and uses the 18-bit result to determine whether there is a match.

Thus, if bits 14-17 (the X field of an instruction) or bit 13 (the I field of an instruction) are nonzero, indexing or indirection may result in DDT finding different search results at different times.

DDT does not check whether the expression is actually an instruction before performing the effective address calculation.

SEARCHING FOR DATA PATTERNS IN DDT

If you enter a question mark (?) while DDT is performing any of the above searches, DDT displays:

```
Searching: addr/ value
```

where addr is the address of the location that will next compare, and value is the contents of addr.

To abort the search, enter any character other than question mark (?). DDT stops searching, and waits for more input. The character that you enter to terminate the search is otherwise ignored.

Each of the above search commands restores the prevailing display mode.

<ESC>M is a command that addresses a DDT location that contains a search mask used to prevent specified bits in the memory word from being considered during the search. This mask is used only by <ESC>W and <ESC>N, not by <ESC>E. DDT logically ANDs the search mask with the memory word before making the comparison, but does not change the memory word. If DDT finds a match, it displays the entire word.

DDT sets the search mask to 777777,,777777 (compare all 36 bits) by default.

To set the search mask, enter:

```
expr<ESC>M
```

where expr evaluates to the required bit pattern.

For example, to search for all of the RADIX50 references to MAIN. (user input is in lowercase):

```
<ESC><ESC>5t           ;Set timeout mode to RADIX50.
37777,,777777<ESC>m   ;Ignore the left 4 bits.
main.<ESC>5"<ESC>w     ;Enter RADIX50 symbol, start search.

4112/  4 MAIN.        ;DDT displays match found.
4775/  0 MAIN.        ;DDT displays match found.
                        ;Search over, DDT displays blank line.
```

You can also examine and modify the search mask with the examine and deposit commands described in Chapter 4 (Displaying and Modifying Memory).

CHAPTER 7

MANIPULATING SYMBOLS IN DDT

7.1 OPENING AND CLOSING SYMBOL TABLES

Each separate program module has its own symbol table. When displaying a value symbolically, if more than one symbol is defined with that value, DDT displays the first global symbol found. When searching for a symbol, DDT searches the "open" symbol table first. For display purposes, DDT treats local symbols found in the open symbol table as global symbols. DDT appends a pound-sign (#) to local symbol names that it finds in a symbol table that is not open. For example:

```
SYMBL1#
```

where SYMBL1 is a local symbol that DDT found in a symbol table that is not open.

If you enter an expression that contains a symbol that is defined in more than one of your program modules, DDT uses the value of the symbol that is contained in the open symbol table. If the symbol is not defined in the open symbol table, or if there is no open module and there is not a global definition of the symbol, DDT displays:

```
M
```

To open the symbol table of a program module, enter:

```
name<ESC>:
```

where name is the name of the program module as specified by the TITLE pseudo-op in your MACRO-10 program (or the equivalent mechanism in a higher-level language program). DDT closes any currently open symbol table and opens the symbol table associated with module name.

To close the open symbol table, enter:

```
<ESC>:
```

MANIPULATING SYMBOLS IN DDT

7.2 DEFINING SYMBOLS

To redefine a symbol or to create a new symbol in the current symbol table, enter:

```
expr<symbol:
```

where expr is any legal DDT expression, and symbol is the symbol name.

To define symbol as the address of the open location, enter the command:

```
symbol:
```

If there is no open location, DDT uses the address of the last location that was open. DDT defines symbol as a global symbol. If you previously used symbol as an undefined symbol, DDT inserts the correct value in all the places you referenced symbol, and removes symbol from the undefined symbol table.

7.3 SUPPRESSING SYMBOL TYPEOUT

To prevent a symbol from being displayed, enter:

```
symbol<ESC>K
```

where symbol is the symbol to be suppressed. DDT still accepts symbol as input, but no longer displays symbol as output.

To suppress the last symbol that DDT displayed (in an address, in the contents of a memory word, or in the evaluation of an expression), enter:

```
<ESC>D
```

DDT suppresses the last symbol displayed, and then redisplayes the current quantity. DDT does not display its usual three spaces between the command and the displayed value.

In the following example, assume that symbol SIZE is defined as 3. User typein is lowercase (<LF> does not appear on the terminal screen).

```
start/  JFCL 0   <LF>
LOOP/   AOS 1   <LF>
LOOP+1/ MOVE 2,1 <ESC>dMOVE 2,1 <LF>
START+3/ MULI 2,SIZE <ESC>dMULI 2,3
```

To reactivate a symbol for typeout, redefine the symbol. For example, to reactivate the display of symbol SIZE, above, enter:

```
size<size:
```

Note that SIZE is now defined as a global symbol, even if it was previously a local symbol.

MANIPULATING SYMBOLS IN DDT

7.4 KILLING SYMBOLS

To remove a symbol from the symbol table, enter:

```
symbol<ESC><ESC>K
```

DDT removes symbol from the symbol table, and no longer displays symbol or accepts symbol as input.

7.5 CREATING UNDEFINED SYMBOLS

It is sometimes convenient to use symbols that have not yet been defined. To create an undefined symbol, enter:

```
symbol#
```

where symbol is the undefined symbol name. DDT enters symbol in the undefined symbol table. When you later define the symbol, DDT enters it into the defined symbol table, removes it from the undefined symbol table, and enters the correct value in all locations where you referenced the symbol.

You can use undefined symbols only as parts of expressions that you are depositing to memory. Undefined symbols can be either fullword or right-halfword values; they cannot be used as the A or X fields of an instruction, or as the left-halfword of an expression.

7.6 FINDING WHERE A SYMBOL IS DEFINED

To determine the modules in which a symbol is defined, enter:

```
symbol?
```

where symbol is the name of the symbol. DDT displays the name of each program module in which symbol is defined. If the symbol is a global symbol, DDT displays a "G", as:

```
sym?  
MAIN. G
```

DDT does not display G following a local symbol found in the open symbol table. When DDT has searched the entire symbol table, it displays a blank line.

7.7 LISTING UNDEFINED SYMBOLS

To get a list of all currently undefined symbols, enter:

```
?
```

DDT displays a list containing each undefined symbol.

MANIPULATING SYMBOLS IN DDT

7.8 LISTING SYMBOLS

To get a list of all symbols starting with a certain character or set of characters, type:

```
sym<ESC>?
```

where sym is the set of characters that all the symbols start with. DDT lists all symbols starting with sym, the modules where they are defined, and the values that symbols are defined as.

For example, typing the following command will list all symbols starting with TECO:

```
TECO<ESC>?
```

```
TECO      TECO      600030
TECO01    TECO      600040
TECO02    TECO      600047
TECO03    TECO      600055
```

CHAPTER 8

INSERTING PATCHES WITH DDT

To replace the instruction at the open location with a series of instructions and test the new instructions without reassembling your program, you can use the DDT patch function. DDT deposits (in a patching area) the replaced instruction, the new series of instructions, and one or more JUMPA instructions back to the main line of your program. DDT also deposits (in the location that contains the replaced instruction) a JUMPA instruction to the first word of the patch.

To insert a patch that will be executed before the instruction at the open location, enter:

```
{expr}<ESC><
```

where expr is the start of the patching location, and defaults first to PAT.., then to PATCH. EDDT defaults to PAT (an area created during the monitor build), PAT.., and PATCH, in that order. If you do not enter expr, and DDT finds none of the default symbols, DDT uses the value contained in JOBDAT location .JBFF as the address to begin the patch. If expr is a symbol (or the default), DDT updates the symbol table when you terminate the patch, so that the symbol identifies the first word after the patch that you just terminated.

If there is no open location when you initiate the patch, DDT displays "?" and sounds the terminal buzzer or bell.

NOTE

If expr is an AC address, or resolves to a value less than 0,,140, DDT displays "?" and sounds the terminal buzzer or bell.

When you issue a command to start a patch, DDT saves the address of the open location, closes the open location, changes the current location to the first word in the patching area, and opens that word. DDT also displays the address and contents of the first word of the patching area. For example:

```
<ESC><  
PAT../ 0
```

You can now enter the patch, using deposit instructions (the expr<LF> format is probably most useful). DDT updates the current and open locations according to the rules for the command that you use.

INSERTING PATCHES WITH DDT

To terminate the patch, enter:

```
{expr}<ESC>{n}>
```

where expr is the last word of the patch you are entering, and n is the number of returns possible from execution of the patch. The default for n is 2, allowing for a return to 1 + the address of the instruction being replaced, and for a "skip return" to 2 + the address of the instruction being replaced.

When you terminate the patch, DDT deposits the instruction being replaced into the first location following the current location, unless:

- o display is not suppressed by ! AND
- o the current location is zero AND
- o the current location is closed OR you omitted expr

in which case DDT deposits the instruction being replaced into the current location. This prevents the patch from containing unintended null words.

DDT deposits n JUMPA instructions in the locations immediately following the one in which it deposited the original program instruction. The first JUMPA instruction has 1 in its A field, and jumps to 1 + the address of the replaced instruction, the second JUMPA instruction has 2 in its A field and jumps to 2 + the address of the replaced instruction, and so on. The AC numbers are used for identification purposes only. Any JUMPA instruction beyond the sixteenth contains 17 in its A field.

DDT then changes the current location to the location that was open when you initiated the patch, deposits in the current location a JUMPA instruction to the first word of the patch that you entered, and displays the address, original contents, and new contents of the current location. The current location is "open", and can be modified by your next command.

If you default expr, or enter a symbol in the {expr}<ESC>< command, when you terminate the patch, DDT redefines the symbol that identifies the start of the patch. If DDT used the value contained in JOB DAT location .JBFF as the address of the patching area, DDT changes the values contained in .JBFF and the left half of JOB DAT location .JB SA. In all cases, the new value is the address of the memory location after the last word of the patch.

By default, there are 100 (octal) words in the patching area. DDT does not check whether your patch overflows the patching area. You can control the size of the patching area with the /PATCHSIZE switch in LINK.

NOTE

DDT allows you to use other DDT commands while you are in the process of entering a patch. DDT does not check whether the current and open locations are in the patching area, or whether you are entering patch instructions in sequence. When you terminate the patch, DDT deposits the instruction being replaced in the current location regardless of whether the current location is in the patching area.

INSERTING PATCHES WITH DDT

To insert a patch that will be executed after the instruction at the open location, enter:

```
{expr}<ESC><ESC><
```

where expr is the address of the patching location (PAT.. is the default). The results are the same as inserting the patch before the instruction as above, except:

- o When you open the patch DDT deposits the replaced instruction in the first word of the patch.
- o When you terminate the patch, DDT deposits the first JUMPA instruction (rather than the instruction being replaced) in the first location following the current location unless:
 - > display is not suppressed by ! AND
 - > the current location is zero AND
 - > the current location is closed OR you omitted expr

in which case DDT deposits the first JUMPA instruction in the current location. This is to prevent the patch from containing unintended null words.

NOTE

If expr is an AC address, or resolves to a value less than 0,,140, DDT displays "?" and sounds the terminal buzzer or bell.

Figure 8-1 illustrates the patching function. The program being patched is X.MAC (see Figure 2-1). The patch inserts a SKIPN instruction that is to be executed after the instruction at START+4.

Figure 8-1: Annotated Patching Session

DDT OUTPUT	USER INPUT	EXPLANATION
START+4/ MOVE 2(IDX)		As a result of your last command, DDT displays the contents of START+4.
	<ESC><ESC><	Enter <ESC><ESC>< to start the patch.
PAT../ 0 MOVE 2(IDX)		DDT displays the address and contents of the first word of the patch area, and deposits the instruction from START+4 in the first word of the patch.
PAT../+1/ 0		DDT displays the address and contents of the next word of the patch area.
	pat..=	Check the address of PAT.." (the first word of the patch area).

INSERTING PATCHES WITH DDT

Figure 8-1: Annotated Patching Session (Cont.)

DDT OUTPUT	USER INPUT	EXPLANATION
14432		DDT displays the current address of "PAT..".
	skipn 1,0<ESC>2>	Enter the new instruction, and terminate the patch with a normal return and one skip return by entering <ESC>2>.
PAT..+2/ 0	JUMPA 1,START+5	DDT displays the next word of the patch area, then deposits a JUMPA instruction to 1 + the address of the replaced instruction.
PAT..+3/ 0	JUMPA 2,START+6	DDT displays the address and contents of the next word of the patch area, then deposits a JUMPA instruction to 2 + the address of the replaced instruction.
START+4/ MOVE 2(IDX)	JUMPA STACK+10	DDT displays the address and original contents of the replaced instruction, then deposits and displays a JUMPA instruction to the first word of the patch. START+4 is the current location, and is "open".
	pat..=	Check the address of the patch area.
14436		DDT updated "PAT..".

Figure 8-2 shows the terminal display as it actually appears when you insert the patch described above. Your input is in lowercase.

Figure 8-2: Terminal Display of Patching After an Instruction

```

START+4/ MOVE 2(IDX) $$<
PAT../ 0 MOVE 2(IDX)
PAT..+1/ 0 pat..=14432 skipn 1,0$2>
PAT..+2/ 0 JUMPA 1,START+5
PAT..+3/ 0 JUMPA 2,START+6
START+4/ MOVE 2(IDX) JUMPA STACK+10 pat..=14436

```

INSERTING PATCHES WITH DDT

Figure 8-3 shows the terminal display when inserting the same patch before the instruction at START+4. You enter the instruction in the form expr<LF> (user input is lowercase). Note the use of the patch termination command without expr and without n.

Figure 8-3: Terminal Display of Patching Before an Instruction

```
START+4/  MOVE 2(IDX)  $<
PAT../   0    .=14432  skipn 1,0
PAT../+1/ 0    $>
PAT../+1/ 0    MOVE 2(IDX)
PAT../+2/ 0    JUMPA 1,START+5
PAT../+3/ 0    JUMPA 2,START+6
START+4/  MOVE 2(IDX)  JUMPA STACK+10  pat..=14436
```

To abort the patch you are entering, enter:

```
<ESC>0<
```

DDT displays 3 spaces (or a tab, depending on the TTY control mask) and changes the current location to the location that was open when you initiated the patch. The symbol that denotes the start of the patching area is unchanged. Any deposits that you made as part of the patch remain in the patching area. This allows you to restart the same patch, or to write over the patch with a new one.

CHAPTER 9

FILDDT

9.1 INTRODUCTION

FILDDT is a utility used to examine and change disk files and physical disk blocks. You can also use FILDDT to examine monitor crash dumps, and to examine and change the running monitor or running jobs. With FILDDT, you can look at .EXE files as if they had been loaded with the monitor GET command, or as if they were binary data files.

In selecting a disk file, the monitor, or a running job, with FILDDT, you are really establishing the virtual address space that FILDDT accesses. When discussing the contents of that virtual address space, where the contents can be any of the above objects, this chapter uses the term target.

Once you have accessed a target you can examine and modify it with the DDT examine and modify commands, and then save it with your modifications. You can use all of DDT's commands for examining and modifying memory, but you cannot use any commands that cause the execution of program instructions, such as <ESC>X, <F5>G, and so on. If you attempt to execute a program instruction, DDT sounds the terminal buzzer or bell.

9.2 USING FILDDT

There are two command levels in FILDDT. This document refers to these two levels as FILDDT command level and DDT command level.

FILDDT command level accepts FILDDT commands to control session parameters and to select the target. When at this level, FILDDT displays the prompt:

File:

Once you access a target, FILDDT enters DDT command level. At this level, use DDT commands to examine and modify the target.

FILDDT

The syntax to use at FILDDT command level is:

```
dev:file.ext[path]/switch/switch
```

where dev:file.ext[path] is the TOPS-10 file specification, and switch is a FILDDT command. The commands are described below. With a FILDDT command you can:

- o request HELP on FILDDT
- o specify the target to be examined
- o establish certain parameters about the operations that you can perform (enable patching, for example)
- o enter DDT command level

A FILDDT command can have more than one of the above effects.

At TOPS-10 command level, start FILDDT by entering:

```
R FILDDT
```

FILDDT enters FILDDT command level and prompts:

```
File:
```

9.2.1 FILDDT Commands

There are two classes of FILDDT-level commands; those that select the target that FILDDT is to access and those that establish what function FILDDT is to perform for the target (enable patching, extract symbols, and treat an .EXE file as data).

The following are the targets (virtual address spaces) that FILDDT can access, and the commands that select them:

- o disk files /F (default)
- o disk structures /U
- o the running monitor /M
- o running jobs /J

To examine a running job or the running monitor, you must have PEEK or SPY privileges.

The following are the functions you can select for FILDDT to perform on the target and the commands that select them:

- o load the file (used with /S) /F
- o treat file as pure binary data /D
- o enable patching /P
- o load symbol table only from file /S

To patch the running monitor or a running job, you must have POKE privileges.

FILDDT

To get HELP, enter:

/H

FILDDT displays a very brief description of the FILDDT commands and redisplay the File: prompt.

9.2.2 Symbols

To enhance performance, FILDDT uses a symbol table which it builds in its own address space, rather than one which exists in the target address space.

FILDDT automatically extracts symbols from the first .EXE file it loads during a session to build its internal symbol table. Once FILDDT has an internal symbol table, it ignores any symbols in subsequently loaded .EXE files unless you use the /S command.

9.2.3 Establishing Formats and Parameters

/F

Use the /F command in conjunction with the /S command, to load the same file from which FILDDT copies the symbol table, as:

file-spec/S/F

/D

By default, FILDDT loads .EXE files in virtual memory as if they were to be executed. When you give the /D command you can look at an .EXE file as if it were a data file. FILDDT then loads the entire file (including the .EXE directory blocks) as a binary file, starting at virtual location zero.

/P

The /P command enables patching (lets you modify) the target. If you do not enter /P, you can only examine the target.

/S

The /S command tells FILDDT to copy the symbol table from the file you named in the command. FILDDT then again prompts you with File:

9.2.4 Selecting the Target

To select a disk file, you need only name the file. This is the default, and requires no explicit command switch. Enter:

file-spec<RET>

FILDDT loads the file. If FILDDT does not already have an internal symbol table and file-spec names an .EXE file, FILDDT builds an internal symbol by default. FILDDT then enters DDT command level.

FILDDT

/J

To examine a running job, enter:

number/J

where number is the job number. You must have PEEK or SPY privileges to examine a running job, and POKE privileges to modify the monitor or a running job.

/M

To examine the running monitor, enter the /M command with no file specification, as:

/M

You must have PEEK or SPY privileges to examine the running monitor, and POKE privileges to modify the running monitor.

/U

To examine a disk structure, use the /U command:

disk-name/U

where disk-name is the logical name of the disk structure. If you use the logical name of a multi-disk structure, you can examine and patch the entire logical disk. If you use a physical disk name, you are restricted to that physical disk.

9.2.5 Exiting FILDDT

When you are through examining and modifying the target, save the modified file by entering:

<CTRL/E>

FILDDT closes the file, saving any changes that you have made, and again prompts you for a file name.

Any symbol table that you have loaded (explicitly or by default) remains loaded until you specify another with the /S command.

If you have modified symbols, FILDDT also modifies the symbol table of the disk file, if one of the following occurred:

- o FILDDT automatically loaded the symbol table.
- o you loaded the symbol table and entered DDT command level by entering:

file-spec/S/F

FILDDT sometimes runs out of memory when you use the <CTRL/E> command to save files without exiting FILDDT. If FILDDT runs out of memory while loading a file, it displays the message:

? Not enough memory for file pages

FILDDT

If FILDDT runs out of space while building a symbol table, it displays the message:

? Not enough memory for symbols

To reclaim all of your available memory, exit FILDDT with the <CTRL/Z> command, and then restart FILDDT with the TOPS-10 command R FILDDT. Note that this technique restores standard virtual addressing conditions, as if you had used the <ESC>U command. See Chapter 11 (Physical and Virtual Addressing Commands) for more information about virtual addressing conditions.

To close the file, save all modifications (as with <CTRL/E>, above) and exit from FILDDT, enter:

<CTRL/Z>

If you exit FILDDT by entering <CTRL/C>, changes that you make to a disk file can still be in FILDDT's output buffer; if so, they will NOT be saved. However, modifications to the monitor and running jobs take effect as you enter them.

When you exit FILDDT with <CTRL/Z>, you can save FILDDT with its internal symbol table. This saves time if you often use FILDDT to debug a specific target (such as the monitor) that has a very large symbol table.

Start FILDDT, load the symbol table, then exit with <CTRL/Z>. Use the TOPS-10 SAVE command to create a copy of FILDDT to be used with that specific file.

CHAPTER 10

EDDT

EDDT is used to debug the monitor. You can run EDDT in executive mode to debug the running monitor, or in user mode to examine and patch the monitor .EXE file.

10.1 EXECUTIVE MODE

When you use EDDT in executive mode, it appears as if you were running the monitor as a user job with DDT merged in. You can set breakpoints, examine and modify memory, and perform all other DDT functions. When at a breakpoint, timesharing is suspended, and you have total control of the system.

You can run EDDT in executive mode only from the CTY. To obtain faster response than from a printing terminal, you can redirect the CTY (only on a KL-10) to a DH-11 line that is connected to a video terminal (see the TOPS-10/TOPS-20 RSX-20F System Reference Manual).

To use EDDT in executive mode, you must invoke it when booting the monitor. EDDT is built and loaded with the monitor, but if you do not invoke it when booting the system, it is discarded to save space. Invoke EDDT by using the /E switch when giving BOOT the name of the monitor file:

```
BOOT>file-spec/E
```

where file-spec is the name of the monitor file that BOOT is to load.

After receiving the EDDT prompt, enter:

```
DEBUG<ESC>G
```

This tells EDDT to start the monitor in debugging mode, in which EDDT remains in memory. The monitor goes through a minimal start-up dialog and then begins timesharing in "DEBUG" mode.

Once timesharing has begun, enter EDDT by typing <CTRL/D> on the CTY.

The monitor traps <CTRL/D>, and calls an internal subroutine that executes a JSR to DDT location \$0BPT (dollar sign, zero, BPT). This causes EDDT to suspend execution at the unsolicited breakpoint, and to display:

```
$0B>>addr/ instr
```

where addr is the monitor location following the JSR instruction and instr is the instruction at addr.

EDDT

Timesharing is suspended and you can perform any DDT functions.

If the system is hung (and EDDT has been kept in memory), you may be able to enter EDDT through the PARSER. On the CTY, type:

```
<CTRL/\>          (control backslash)
```

When you receive the following prompt:

```
PAR>
```

enter:

```
HALT
```

to freeze the machine state. The parser again prompts PAR>. Now enter:

```
EXAMINE KL
```

to type out the machine state at the time of the HALT. At the parser prompt, enter the command:

```
JUMP 401
```

to enter EDDT. The monitor is frozen in its state at the time of the HALT. The start address of EDDT is 401.

The dialog on the CTY after you enter <CTRL/\> might appear as follows (your input is in lowercase):

```
PAR>halt
PAR>examine kl
PC/ 1450
VMA/ 405452
PI ACTIVE: ON, PI ON: 000, PI HOLD: 020, PI GEN: 000
NO KL PC FLAGS ARE SET
PAR>jump 401
EDDT
```

You can now use DDT commands to debug the monitor.

NOTE

The <ESC>Y command in executive mode EDDT reads from the console paper tape reader.

10.2 USER MODE

You can use EDDT in user mode, to examine and patch the monitor .EXE file, and then use the TOPS-10 SAVE command to save (and rename, as appropriate) the new version of the file. You can then boot and test the patched version later, during stand-alone time.

Invoke user-mode EDDT by first using the TOPS-10 GET command:

```
GET filnam
```

where filnam is the name of the monitor .EXE file. Then use the TOPS-10 DDT command. EDDT prompts:

```
DDT
```

EDDT

EDDT does not prompt EDDT because you are in user mode rather than executive mode. You can now use DDT commands to set breakpoints, examine, and patch the monitor .EXE file. When you exit EDDT, you can use the TOPS-10 SAVE command to save the .EXE file. If you left breakpoints set when you exited, they are still active when you boot the monitor using the saved .EXE file.

CHAPTER 11

PHYSICAL AND VIRTUAL ADDRESSING COMMANDS

All TOPS-10 DDTs (including FILDDT) can do their own page mapping. The commands described in this chapter allow you to set parameters to govern the interpretation of the address space which you are examining. You can control the mapping of the address space you are examining by choosing to use or bypass the user process table (UPT) or the executive process table (EPT). You can choose which special pages table (SPT) to use, and which hardware register block to use. Other commands allow you to emulate either KI-paging or KL-paging, control address relocation, and set memory protection limits. In each of the following commands, the argument (page, addr, n) defaults to zero.

NOTE

The DDT commands <ESC>G, <ESC>P, and <ESC>X have side effects that affect your control over physical and virtual addressing. In addition to their normal functions, these commands also do the following:

- o restore normal virtual addressing as if <ESC>U had been given (<ESC>X does NOT do this)
- o set the FAKEAC flag (as if <ESC>U had been given)
- o clear the relocation factor (as if 0<ESC>8U had been given)
- o reset the address-protection address to infinity (377777,,777777)
- o restore the active hardware register block to the one in use before any <ESC>4U command was given

COMMAND

EXPLANATION

<ESC>U

This command enables memory mapping by standard TOPS-10 virtual addressing. When you give this command, DDT restores the virtual addressing conditions that were in effect before any {<ESC>}<ESC>nU (where 0<=n<=2) commands were given, and sets DDT's FAKEAC flag, thereby forcing DDT to interpret memory addresses 0-17 as DDT's own internal "registers", in which the user's registers were saved.

PHYSICAL AND VIRTUAL ADDRESSING COMMANDS

<ESC><ESC>U

This command enables DDT to use actual physical addresses when accessing memory, and clears DDT's FAKEAC flag, causing DDT to interpret memory addresses 0-17 as the hardware registers 0-17. This command is meaningful only when using EDDT in executive mode, or when using FILDDT to look at the running monitor. Although DDT accepts <ESC><ESC>U at other times, this command then produces the same effect as <ESC>U.

The general syntax of the following virtual addressing commands is:

arg<ESC>nU

where n is the function number of the command, and arg is dependent on the function (see the function descriptions below).

Functions 0, 1, and 2 enable you to control memory mapping by selecting the executive process table (EPT), user process table (UPT), or the section map through which mapping occurs. Setting a mapping condition with any one of these functions (0, 1, and 2) also has the effect of clearing the effects of any prior use of one of these functions (0, 1, and 2).

You can also specify the offset into the special pages table (SPT) with functions 0, 1, and 2 by using the following command:

arg<ESC><ESC>nU

where arg is the SPT offset, and $0 \leq n \leq 2$. This form is legal only if KL-paging is in effect.

NOTE

All forms of <ESC>B and <ESC>X are illegal if you have used the page mapping functions (0, 1, or 2) and have not restored standard mapping with the <ESC>U command.

COMMAND	EXPLANATION
page<ESC>0U	This command causes memory mapping to occur through the executive process table (EPT) that is located at physical page <u>page</u> .
offset<ESC><ESC>0U	This command produces the same effect as page<ESC>0U (above), except that <u>offset</u> is an offset (in words) into the SPT.
page1<page2<ESC>0U	This command is an exception to the general syntax, and is legal only under KI-paging. You can select both the user page table (UPT) and the executive page table (EPT) with this command, where <u>page1</u> is the page number of the UPT, and <u>page2</u> is the page number of the EPT. Follow page1 with a left angle bracket (<).
page<ESC>1U	This command causes memory mapping to occur through the user process table (UPT) that is located at physical page <u>page</u> . With this command, you can bypass the EPT.

PHYSICAL AND VIRTUAL ADDRESSING COMMANDS

offset<ESC><ESC>1U

This command produces the same effect as page<ESC>1U (above), except that offset is an offset (in words) into the SPT.

page<ESC>2U

This command causes mapping to occur through the section map at physical page page. This command is legal only if KL-paging is in effect.

offset<ESC><ESC>2U

This command produces the same effect as page<ESC>2U (above), except that offset is an offset (in words) into the SPT. This command is legal only if KL-paging is in effect.

n<ESC>3U

This command determines whether DDT interprets references to memory locations 0-17 as references to hardware registers, or to DDT's own internal "registers" (which normally contain the user-program ACs), by setting or resetting DDT's FAKEAC flag.

If n=0, reset FAKEAC flag (use the hardware registers 0-17).
If n is nonzero, set FAKEAC flag (use DDT's internal registers 0-17).

If you enter a nonzero value for n, DDT stores the value -1.

n<ESC>4U

This command tells DDT to copy hardware register block n ($0 \leq n \leq 7$) to its own internal register block, set the FAKEAC flag, and use hardware register block n as its own registers. If the FAKEAC flag is set when you give this command, DDT first restores the contents of its internal register block to the hardware register block from which they were copied. This command is legal in executive mode EDDT only. Note that the microcode uses register block 7, and any attempt to use this block produces an almost immediate system crash.

addr<ESC>5U

This command copies the 20 (octal) word block located at addr to DDT's internal "registers" and sets the FAKEAC flag.

addr<ESC>6U

This command sets the special pages table (SPT) to addr.

addr<ESC>7U

This command sets the core status table address (CST) to addr.

addr<ESC>8U

This command sets the address relocation factor to addr. DDT adds addr to all user addresses that you enter.

addr<ESC>9U

This command read-and-write-protects all addresses above addr (before adding relocation factor).

PHYSICAL AND VIRTUAL ADDRESSING COMMANDS

n<ESC>10U

This command controls whether KI paging is enabled or cleared.

If n is nonzero, KI paging is enabled.
If n=0, KI paging is cleared.

If you enter a nonzero value for n, DDT stores the value -1.

This command is illegal in executive mode EDDT.

n<ESC>11U

This command controls whether KL paging is enabled or cleared.

If n is nonzero, KL paging is enabled.
If n=0, KL paging is cleared.

If you enter a nonzero value for n, DDT stores the value -1.

This command is illegal in executive mode EDDT.

22<ESC>U

23<ESC>U

These commands specify the type of CPU on which the program is being debugged. 22<ESC>U refers to a KL processor. 23<ESC>U refers to a KS processor.

For DDT, this command is meaningless, because DDT uses the current CPU type. However, these commands may be useful for FILDDT.

You can interrogate DDT to determine the last virtual addressing command that was given for a specific function. The command:

<ESC>nU

where $0 \leq n \leq 11$, returns the address of a DDT location that contains the argument that was given if the command for that function was used, and returns the default value if that function was not used. If you entered a nonzero argument to a command that requires zero or nonzero values (or if the default is nonzero), this location contains -1. You can use DDT commands to examine this location.

The command:

<ESC><ESC>nU

where $0 \leq n \leq 2$, returns the address of a DDT location that contains information that indicates which function you used, and whether you set a page address or an offset. You can use DDT commands to examine this location. This command is illegal for all functions where $n > 2$. If you did not enter any commands affecting functions 0-2 since the last <ESC>U command, the right half of this DDT location word contains zero. Otherwise, the right half contains $n+1$, where n is the number of the command function you used. If you set a page address (with $\text{arg}\langle\text{ESC}\rangle nU$), bit 1 of this word is reset. If you set an offset (with $\text{arg}\langle\text{ESC}\rangle \langle\text{ESC}\rangle nU$), bit 1 of the word is set.

CHAPTER 12

EXTENDED ADDRESSING

You can load your program with LINK so that the program resides in extended sections (sections other than Section 0).

If you are debugging a program with extended sections (also called non-zero sections, or NZS), DDT is automatically loaded into Section 0, started at location 700000. To access non-zero sections, you must issue the <ESC>4M command to enable intersection (global) breakpoints. After you use the <ESC>4M command, you can set intersection breakpoints and execute instructions that cross section boundaries. (Refer to Section 12.2 for more information about intersection breakpoints.)

You can load a normal, Section 0 program into a non-zero section (NZS) using one of the following monitor commands:

```
.RUN prog/USE:n  
.GET prog/USE:n
```

where n is the section number in which to load the program. These commands are documented in the TOPS-10 Operating System Commands Manual.

If the program does not already have DDT loaded, then a DDT command will merge SYS:VMDDT with your program, starting at address 700000 (in Section 0). In this case, DDT will be able to examine and deposit to locations in the program, but you cannot set breakpoints or single-step the program. You can merge VMDDT into a NZS section using the monitor command:

```
.MERGE SYS:VMDDT/USE:n
```

A subsequent DDT command will then start DDT in section "n". When you merge DDT into the same section that you specified in the GET/RUN command, you can immediately set breakpoints and single-step the program.

EXTENDED ADDRESSING

When DDT is first started in Section 0, if it detects an extended-section symbol table pointer, it will attempt to map itself into an extended section so that it can access the symbol table. For example, the monitor works this way. DDT is loaded into Section 0 along with the rest of the monitor's low and high segments, and the symbol table is placed in Section 2. The section chosen is the entry-vector section, if any; otherwise, the section that contains the symbol table is used, or Section 1. If DDT can find a section to use, DDT displays the following message:

```
[DDT - Section 0 mapped into section n for NZS symbol table access]
```

where n is the section number that is actually used. If DDT is unable to find a section where it can be mapped, it displays the following message and continues running:

```
[DDT - Can't access NZS symbol table(s) from Section 0]
```

When your program is running in extended sections, DDT searches for the symbol table first in the entry vector section, if any; otherwise it searches JOBDAT (locations .JBSYM, .JBUSY, and .JBHSM) in Section 0.

Although TOPS-10 does not support Program Data Vectors (PDVs), you can set up your own PDV, and use the \$5M command to specify the address of a PDV to use for the symbol table vector(s).

12.1 BREAKPOINTS

If DDT is running in a non-zero section, breakpoints can be set in any section.

12.1.1 The Breakpoint Block

To set breakpoints in a section other than the section containing DDT, DDT requires an area of storage in the section containing the breakpoint. This storage area, also known as the "breakpoint block," is required for saving global addresses for transferring control between your program and DDT, and for executing single-stepped instructions that refer to memory locations outside their section.

Each section in your program's memory space that contains a breakpoint must have one breakpoint block, located at the same relative local address within the section, of 100 octal words in length. (If two or more sections of the program are mapped together, the breakpoint blocks must also be mapped together.)

Each breakpoint block is contiguous within the section. Breakpoint blocks cannot be extended across section boundaries, and do not wrap around the end of the section to the beginning of the section.

Your program can refer to locations in the breakpoint block; remember, however, that DDT can overwrite this information.

EXTENDED ADDRESSING

12.1.2 Enabling and Disabling Intersection Breakpoints

The section-relative (18-bit) address of the breakpoint block is stored in an internal DDT location. The command <ESC>4M returns the address of that location. The symbol \$4M refers to the DDT location at the address returned by <ESC>4M. Intersection breakpoints are enabled when \$4M contains the locations of the breakpoint block.

To specify the address of the breakpoint block, use the following DDT command:

```
n<ESC>4M
```

where n is the address of the breakpoint block, and can be any valid DDT expression (from 20 to 777700). DDT uses only the right half of n, and changes only the right half of the DDT location at \$4M.

To display the location of the breakpoint block, use the following DDT command:

```
<ESC>4M/
```

When this location contains 0, breakpoints are disabled. Therefore, you can use the following command to disable intersection breakpoints:

```
0<ESC>4M
```

While intersection breakpoints are disabled, you cannot set a breakpoint in a section external to DDT, and any breakpoints already set in such a section are lost when you begin program execution with <ESC>P or <ESC>G. For each breakpoint that is lost, DDT displays the following message:

```
% CAN'T INSERT $nB - IN NON-DDT SECTION
```

where n is the breakpoint number.

While intersection breakpoints are disabled, DDT cannot execute the <ESC>X command under the following circumstances:

- o When you try to execute the instr<ESC>X command, and the default section is not the section that contains DDT.
- o When you try to single-step a dangerous instruction and the user program PC is not in the section that contains DDT.

In these cases, when you try to use <ESC>X, DDT rings the terminal bell or buzzer and sets its error message text to:

```
Intersection reference and no $4M global breakpoint/execute block
```

EXTENDED ADDRESSING

12.2 DISPLAYING SYMBOLS IN NON-ZERO SECTIONS

DDT normally uses right-halfword values when searching symbol tables for symbols to display. However, code linked in a non-zero section has symbols defined with the section number in the left-halfword. DDT uses a 30-bit value when searching for a symbol in the following circumstances:

- o when displaying the address of a location
- o when displaying the contents of a location as an address
- o when displaying the Y field of an instruction

When displaying an address, DDT searches for a symbol defined with the 30-bit value of the address. If such a symbol is not found, DDT displays the address in halfword format.

When displaying the Y field of an instruction, DDT searches for a symbol defined with a 30-bit value consisting of:

- o the section number of the address of the word being displayed
- o the section-relative address contained in the Y field of the instruction

If DDT does not find a symbol defined with that 30-bit value, it looks for a symbol defined with the 18-bit value contained in the Y field of the instruction.

Assume a program with the following conditions:

```
Symbol LABL1 is defined as 0,,300
Symbol LABL2 is defined as 3,,300
Location 1,,300 contains 3,,300
Location 1,,301 contains 2,,300
Location 3,,400 contains 200040,,300
(MOVE contents of location 300 to AC 1)
```

When displaying the contents of location 1,,300, DDT displays:

```
1,,LABL1/      LABL2
```

When displaying the contents of location 1,,301, DDT displays:

```
1,,LABL1+1/    2,,LABL1
```

When displaying the contents of location 3,,400, DDT displays:

```
LABL2+100/     MOVE 1,LABL2
```

12.3 DEFAULT SECTION NUMBERS

To reduce the need to type in the section number as part of the address when you specify a location, DDT uses a default section number when you do not specify one. DDT has two section defaulting options:

- o Permanent default section
- o Floating default section

EXTENDED ADDRESSING

The command <ESC>6M returns the address of an internal DDT location that contains section default information. The symbol \$6M refers to the DDT location at the address returned by the command <ESC>6M.

When DDT is in Section 0, the default section number is always 0, regardless of the contents of \$6M.

12.3.1 Permanent Default Section

If the value contained in \$6M is positive (Bit 0 is reset), the permanent default section option is in effect. DDT then takes the left half of \$6M as the section number of any address that you type in without a section number.

Set the permanent default section by typing the following DDT command:

```
n,,0<ESC>6M
```

where n is the section number, and can be any legal DDT expression.

12.3.2 Floating Default Section

If the value contained in \$6M is negative (Bit 0 is set), the floating default section option is in effect. This is the default option (at startup, DDT initializes \$6M to -1). DDT selects the floating default section as follows:

- o If you enter DDT from its normal start address, DDT sets the default section to one of the following:
 - a. the section that contains the program entry vector (if there is an entry vector)
 - b. Section 0
- o If you enter DDT from a breakpoint, DDT sets the default section to the section that contains the breakpoint.
- o If you open a local address between 20 and 777777, DDT sets the default section to the section that contains the open address.
- o If you type in an address that contains a section number (including a symbol that is defined with a section number), DDT sets the default section to the one in the address you typed in.

If you exit DDT with <CTRL/C> or <CTRL/Z>, and then reenter DDT, the current location does not change. If you give a command that takes the current location as its default address argument, DDT sets the floating default section to the section of the current location.

EXTENDED ADDRESSING

In the following example, the DDT screen display is on the left, and explanatory comments are on the right. The entry vector is in section 1. Symbol START is not defined with a section number. User typein is in lowercase.

Screen Display	User Input	Explanation
	3,,place/	Examine location 3,,PLACE.
LABL1		DDT displays the contents.
	<LF>	Type in <LF> to examine the next location.
3,,PLACE+1/ LABL1+2		DDT displays the next location. The floating default section = 3.
	<CTRL/C>	Exit with <CTRL/C>. The current location is 3,,PLACE+1.
@		TOPS-20 prompts you.
	@ddt	Reenter DDT.
DDT		DDT is loaded and ready for your command. The floating default section is 1, because the entry vector is in section 1.
	<LF>	Type in <LF> to examine the next location.
3,,START+2/ LABL1+4		DDT displays the address and contents of the next location. DDT doesn't use the floating default section, because your <LF> command defaults addr to the current location, and uses its section number (3).
	start/	Examine location START. DDT uses the floating default section number because symbol START is defined with no section number.
JFCL 0		DDT displays the contents.
	<LF>	Type in <LF> to examine the next location.
1,,START+1/ MOVE 1,LABL1		DDT displays the address and contents of the location.

EXTENDED ADDRESSING

12.4 EXECUTING SINGLE INSTRUCTIONS

Instructions that are executed by means of the command:

```
instr<ESC>X
```

where `instr` is the instruction for DDT to execute, are executed within the current default section. If that section is not the one that contains DDT, DDT uses the breakpoint block in that section to execute `instr`. If the floating default section option is in effect, and you are unsure of the current default section, use the `addr/` command to open a location in the section in which you wish DDT to execute `instr`. This sets the default section to the section specified by `addr`.

Instructions that are executed by means of the command:

```
instr<ESC><ESC>nX
```

where `instr` is the instruction for DDT to execute, are executed within the section specified by `n`. If you type this command without specifying the section number, DDT uses its current section.

If DDT is to execute the instruction in a section other than the one that contains DDT, intersection breakpoints must be enabled.

If you try to execute `instr` outside DDT's section while intersection breakpoints are disabled, DDT sounds the terminal buzzer or bell, displays "?", and sets its error string to:

```
Intersection reference and no $4M global breakpoint/execute block
```

12.5 ENTERING PATCHES IN EXTENDED SECTIONS

You cannot type in a patch if a patching area does not exist in the section that contains the word to be replaced. To ensure that there is a patching area for each section that contains user-program code, do one of the following:

- o Reserve the same part of each section for patches, and define the patch symbol as `0,,addr`, where `addr` is the local address of the patching area.
- o Use only one patching area, and map it into all the sections that contain user-program code. Define the patch symbol as `0,,addr`, where `addr` is the local address of the patching area.
- o Define a different symbol for each section's patching area, and use the symbol appropriate to the section being patched.

If the left half of `expr` is `0`, DDT defaults the section to the section that contains the open location. If the left half of `expr` is a value that is not the section that contains the open locations, DDT displays the following message:

```
?CAN'T PATCH ACROSS SECTIONS
```


APPENDIX A
ERROR MESSAGES

DDT and FILDDT display error messages to indicate the results of your commands. DDT sometimes (and FILDDT usually) displays these messages on the screen, and at other times displays only a question mark. When only a question mark is displayed, a location internal to DDT usually points to a text string that is the error message. To display the error message, enter the command:

<ESC>?

Following is a list of DDT messages together with explanations of what the messages indicate.

? ABOVE PROTECTION REGISTER LIMIT

The address of the location you tried to display or modify is above the protection register limit, which is set by n<ESC>9U.

? ACTUAL REFERENCE FAILED

A memory reference failed unexpectedly (the page exists and is readable, but the reference failed anyway).

? ADDRESS GREATER THAN 777777

An address to be mapped through a section table has a nonzero section number. This can occur only if you specified a section table with the n<ESC>{<ESC>}2U command.

? ADDRESS BEYOND END OF PHYSICAL MEM

You attempted to examine a physical memory location beyond the end of physical memory. This error occurs only if you have used the <ESC><ESC>U command to enable physical addressing.

? BAD FORMAT FOR .EXE FILE

You specified a file that appears to have an .EXE directory, but the directory is badly formatted or DDT cannot read it because of some other reason.

? BAD \$4M VALUE

You used the n<ESC>4M command where 777700<n<20.

ERROR MESSAGES

? BAD POINTER ENCOUNTERED

DDT does not recognize the type code contained in a page map pointer. This can occur only if you are trying to do your own virtual address mapping, and used the `expr<ESC>{<ESC>}nU` command, where $0 \leq n \leq 2$.

? CAN'T BE WRITE ENABLED

Even though you have automatic write-enable turned on, DDT is unable to write-enable a page that exists and is write-protected.

? CAN'T CREATE PAGE

DDT attempted to create a page and failed, or else is unable to attempt to create the page (see the `<ESC>lW` command).

? CAN'T DEPOSIT INTO SYMBOL TABLE BECAUSE

You tried to define or kill a symbol, but DDT was unable to modify the symbol table. Look up the second part of the error message in this appendix.

? CAN'T DEPOSIT INTO SYMBOL TABLE BECAUSE DEPOSIT FAILED

You tried to define or kill a symbol, but DDT was unable to modify the symbol table, and cannot identify the specific reason.

% CAN'T INSERT \$nB BECAUSE

DDT is not able to access the location where you inserted your breakpoint. Look up the second part of the error message in this appendix. This occurs before DDT tries to execute `<ESC>G`, `<ESC>P`, `<ESC>X`, or `<ESC><ESC>X`.

% CAN'T INSERT \$nB BECAUSE BREAKPOINT IS IN DIFFERENT SECTION

DDT is not able to access the location where you inserted your breakpoint because inter-section breakpoints are not enabled (`<ESC>4M` contains zero). This error occurs before DDT tries to execute `<ESC>G`, `<ESC>P`, `<ESC>X`, or `<ESC><ESC>X`. To enable inter-section breakpoints, deposit the breakpoint block address in the location addressed by the command `<ESC>4M`.

% CAN'T INSERT \$nB BECAUSE MEM REF FAILED

DDT is not able to access the location where you inserted your breakpoint. DDT is not able to identify the reason. This occurs before DDT tries to execute `<ESC>G`, `<ESC>P`, `<ESC>X`, or `<ESC><ESC>X`.

% CAN'T REMOVE \$nB BECAUSE

DDT is not able to access the location where you inserted your breakpoint. Look up the second part of the error message in this appendix. This error occurs when your program enters DDT from a breakpoint.

ERROR MESSAGES

%CAN'T REMOVE \$nB BECAUSE BREAKPOINT IS IN DIFFERENT SECTION

DDT is not able to access the location where you inserted your breakpoint, because inter-section breakpoints are not enabled (<ESC>4M contains zero). This error occurs when your program enters DDT from a breakpoint. To enable inter-section breakpoints, deposit the breakpoint block address in the location addressed by the command <ESC>4M.

% CAN'T REMOVE \$nB BECAUSE MEM REF FAILED

DDT is not able to access the location where you inserted your breakpoint. DDT is not able to identify the reason. This error occurs when your program enters DDT from a breakpoint.

%CAN'T SET BREAKPOINT, \$4M NOT SET

You attempted to set a breakpoint in a section other than the one containing DDT while inter-section breakpoints were not enabled.

? Device must be a disk unit or a file structure

The device that you specified to the /U command is not a disk.

? Explicit structure required with /U

You used the /U command without specifying a device.

? FAILURE ON SWITCHING ADDRESS SPACE

EDDT (Executive mode EDDT only) encountered an error while trying to access the virtual address space where monitor symbols are kept.

? FILOP. failure (n) for input file

The FILOP. call to open the specified file or unit failed with error code n.

?Garbage at end-of-command

FILDDT encountered extra text at a place in the command where there should have been only <RET>.

Intersection reference and no \$4M global breakpoint/execute block

Inter-section breakpoints are not enabled, and:

- o you tried to execute the command instr<ESC>X but the default section is not the section that contains DDT, or
- o you tried to single-step a dangerous instruction but the user-program PC is not in the section that contains DDT.

ERROR MESSAGES

? I/O error

An I/O error occurred when FILDDT attempted to read or write to the file or unit.

? I/O error reading command file

DDT encountered an I/O error when reading the command file that you specified to the <ESC>Y command.

? Illegal job number

You entered an illegal job number with the /J command.

? Illegal switch "c" specified

You entered a command other than /D, /F, /H, /J, /M, /P, /S, or /U.

? Incorrect symbol table pointer

FILDDT is unable to read the symbol table specified by the symbol table pointer in the file.

? Input device must be a disk

The device you specified is not a disk.

? Insufficient memory to read EXE file directory

FILDDT does not have enough free memory to read in the directory section of the .EXE file that you specified.

? INVALID DDT INTERNAL ADDRESS

You addressed an internal location that is not defined. This is most likely to occur after you use a command that returns a value (such as <ESC>M) to examine a DDT location and then use <LF> or <BKSP> to look at nearby memory.

? /M illegal with /D, /F, /S, or /U

You entered an illegal command along with /M.

M

You entered a symbol that is defined in more than one module. You can select the correct symbol by opening the symbol table associated with that module, using the module<ESC>: command.

? NO READ ACCESS

You tried to display a word in a page to which you do not have read access.

ERROR MESSAGES

? No such file structure

COMND% and DEVST% think you supplied a disk name in a STRUCTURE command, but no unit with that name was returned by MSTR%.

? Not enough memory for file pages

FILDDT does not have enough free memory for its file page buffers.

NOTE

FILDDT sometimes runs out of memory when you use the <CTRL/E> command to save files without exiting FILDDT. If this is the case, exit with the <CTRL/Z> command, and then restart FILDDT with the TOPS-10 command: R FILDDT.

? Not enough memory for symbols

FILDDT does not have enough free memory to read in the symbol table from the specified .EXE file. See the note above.

? NOT IN CORE

You tried to map through a page map pointer (in a UPT, SPT, or section table) that addresses a page that is swapped out. This can occur only if you are trying to do your own virtual address mapping, and used the expr<ESC>{<ESC>}nU command, where 0<=n<=2.

% Not in .EXE format -- Data file assumed.

A file was specified without /D which is not in .EXE file format. FILDDT assumes it is a data file.

? NOT WRITABLE

You tried to modify a word in a write-protected page. To enable writing on protected pages, use the <ESC>0W command.

? Null filename illegal

You did not enter a file specification to a command that requires one.

? Null file spec with /F

You entered a /F command without a file specification.

? OUTPUT error on CLOSE

An error occurred when FILDDT tried to CLOSE the file.

ERROR MESSAGES

? PAGE DOES NOT EXIST

You tried to display a word in a nonexistent page.

? Patching is not enabled

You attempted to modify a file, a disk, the monitor, or a job but did not give the /P command.

% Patching the running monitor is illegal

You entered an ENABLE PATCHING command and then gave a PEEK command.

? PEEK FAILED

You tried to PEEK at the monitor, but do not have PEEK, POKE, or [1,2] privileges enabled.

? /S illegal with /D or /U

You used the /S command with a command other than /F.

% Symbols cannot be extracted from a data file

You entered the command filnam/S/F, where the file specified by filnam is not in .EXE format. FILDDT assumes it is a data file and does not attempt to read in any symbols from the file.

? Symbols cannot be extracted from a data file

You entered the command filnam/S, where the file specified by filnam is not in .EXE format. FILDDT prompts for a new command.

U

You entered a symbol that DDT cannot locate in any symbol table. Cure this by entering the correct symbol, or by defining the symbol with the {expr<}symbol: command.

? UNEXPECTED MOVEM FAILURE

DDT could not deposit to memory even though the page exists and is write-enabled.

% Update of file's symbol table failed

FILDDT was unable to write the modified symbol table back to the file after you gave a <CTRL/Z> or <CTRL/E> command.

GLOSSARY

bit

Bit is a contraction of "binary digit". A bit is the smallest unit of information in a binary system of notation. It is the choice between two possible states, usually designated as zero and one. Bits of data are often used as flags to indicate on/off or yes/no conditions.

breakpoint

A breakpoint is a location in a program's executable code that has been modified so that if the program attempts to execute the instruction at that location, control passes to DDT before the instruction is executed.

current display mode

The current display mode is the mode in which DDT displays the next word (unless there is an intervening command that changes the current display mode). Also known as the current typeout mode.

current quantity

The current quantity is the most recent of:

- o the last 36-bit quantity that DDT displayed
- o the 36-bit evaluation of the last expression that you entered as an argument to a command that deposits to memory

This value is often used as the default argument for the next command. Also known as the last value typed.

current typeout mode

See current display mode.

current location

The current location is a memory word that has been referenced by an earlier DDT command. The address of the current location is the default address for most DDT commands.

current location stack entry

The location that will become the current location as a result of the next <ESC><RET> command.

GLOSSARY

current radix

The current radix is the radix in which DDT displays values.

debugging

Debugging is the process of finding and removing program errors from programs.

EDDT

EDDT is the DDT variant that is used to debug executive-mode programs.

FILDDT

FILDDT is the DDT variant that is used to examine and modify disk files and disk structures. FILDDT is also used to examine and modify the running monitor and other running jobs.

jiffy

A jiffy is a unit of time defined as one AC (alternating current) cycle. If your line power has a frequency of 60 Hz., a jiffy is one sixtieth of a second (about 16 milliseconds). If your line power has a frequency of 50 Hz., a jiffy is one fiftieth of a second (20 milliseconds).

last value typed

See current quantity.

location

A location is a numbered or named place in storage or memory where a unit of data or an instruction can be stored. This manual also uses the terms word and memory word.

location counter

The location counter is a memory word that contains the address of the current location.

location sequence stack

The location sequence stack is a stack in which DDT stores the addresses of locations used earlier. DDT uses the stack to access these locations again without having you explicitly enter the address of each of the locations. DDT references these addresses in a last-in, first-out manner.

open location

The open location is a memory word that you can modify with your next DDT command.

prevailing display mode

The prevailing display mode is a user-defined default display mode. DDT displays memory words in the prevailing mode unless you specify a temporary display mode. You can restore the prevailing mode with the <RET> command. See Chapter 4 (Displaying and Modifying Memory) for a list of other commands that restore the prevailing display mode.

GLOSSARY

reset

Reset refers to the zero condition of a bit or flag. A bit that is zero is said to be reset. To reset is the verb that refers to the act of turning the bit off, "clearing" the bit, or making it zero.

set

Set refers to the nonzero condition of a bit or flag. A bit that is nonzero is said to be set. To set is the verb that refers to the act of turning the bit on, or making it nonzero.

single-stepping

Single-stepping is the process of executing program instructions one-at-a-time using DDT, to verify the result of each instruction.

target

Target refers to the contents of the virtual address space that FILDDT is accessing. The virtual address space may contain a disk structure, a disk file, a running job, or the running monitor.

temporary display mode

The temporary display mode is a short-term, user-selected display mode which overrides the prevailing display mode. Temporary display mode remains in effect until you enter <RET>, <LF>, <BKSP>, or <TAB>. Also known as the temporary timeout mode.

temporary timeout mode

See temporary display mode.

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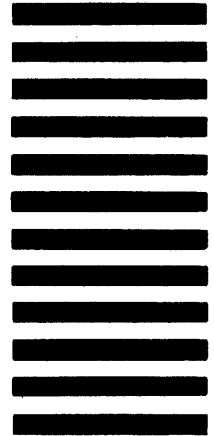
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