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TITLE	DDT-UP OCTAL-SYMBOLIC DEBUGGING PROGRAM
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SOURCE LANGUAGE	

DDT-UP OCTAL-SYMBOLIC DEBUGGING PROGRAM

DECUS Program Library Write-up

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DDT-UP is an octal-symbolic debugging program for a 4K PDP-8 which occupies locations 5600 through 7667. The mnemonics for the eight basic instructions are defined internal to this area. Other symbols are stored, four locations per symbol, from 5577 down towards 0000. The mnemonics for the standard OPR and IOT group instructions (see complete list on page 8) are initially defined in this area. Thus the highest location initially available to the user is 5363. Beginning at this location the user may define symbols one at a time using the comma (,) operator.

From the Teletype, the user can symbolically examine and modify the contents of any memory location. DDT-UP allows the user to punch a corrected program in CBL format.

DDT-UP has a breakpoint facility to help the user run sections of his program. When this facility is used, the debugger also uses location 0005.

Loading, Starting, Restarting

DDT-UP is read in by any loader. (See the CBL or XCBL Memos of March 1, 1967.) After it has been read in and the reader turned off, DDT-UP is started at 7000. Locations above 7667 are always preserved. Below 5364 DDT-UP uses only location 0005 and those locations immediately below 5364 necessary to accommodate the symbol table.

During execution of the user's program or operation of DDT-UP itself, it may be restarted at 7000.

Constituents of Octal-Symbolic Expressions

OCTAL DIGIT - one of the characters 0, 1, ..., 7

OCTAL NUMBER - one to six octal digits, evaluated modulo $(10000)_8$

SYMBOL - one to six characters chosen from 0, 1, ..., 9, A, B, ..., Z, and ".", but not an octal number

TERM - SYMBOL or OCTAL NUMBER

EXPRESSION - one or more terms separated by either +, SPACE, &, or -

+ - two's complement plus

- - unary or binary two's complement minus

SPACE,& - inclusive OR

* - means indirect addressing when immediately following an addressable instruction; when alone, it has the value of the "current location"

Z - (TYPE OUT ONLY) Indicates page zero is addressed (bit 4 is 0).

Type-in BCD - Typing a) following a term causes the value of that term to be taken as the trimmed BCD codes of the first two characters of the term. If the term is a single character, it is assembled in bits 0-5, and bits 6-11 are set to 00.

Illegal Characters - DDT-UP responds with a BELL, and the character is ignored.

Undefined Symbols - DDT-UP responds with a ? , and the expression is ignored.

RUB OUT or ? - DDT-UP responds with a ? , and the expression is ignored.

Examinations

One of the following characters typed after an expression (typed in or out) causes DDT-UP to open the location specified by the expression, and type out the contents of the location as below. If no location was already open, both the mode and the current location (*) are set.

<u>Character</u>	<u>Mode of Examination</u>
/	Instruction: mnemonic with symbolic address for addressable; mnemonic with octal address for <u>OPR</u> and <u>IOT</u> groups.
:	Symbol
[(shift K)	Octal number
] (shift M)	BCD

Equivalences

One of the following characters typed after an expression (typed in or out) causes DDT-UP to type that expression in the mode as below.

<u>Character</u>	<u>Mode of Equivalence</u>
←	Instruction (as in examination above)
\$	Symbol
=	Octal number
\ (shift L)	BCD

Current Location

* has the value of the location last opened when no location was already opened.

Carriage Return

If a location is open, an expression typed in followed by a CR causes DDT-UP to set the contents of that location to the value of the expression.

Miscellaneous

- LF First acts like a CR and then opens location *+1 in the current mode.
- ↑ First acts like CR and then opens location *-1 in the current mode.
- # # has the value of the expression last typed in or out.

Typing Mode for Locations

Locations typed out by DDT-UP prior to its typing one of the examination characters are normally typed out as symbols. However, the user may change this mode of type out:

- ctrl O (the letter) - set the mode in which locations are typed to octal
- ctrl S - set the mode in which locations are typed to symbolic

Limits, Mask

The lower and upper limits (LL and UL) for zeroing, searching, and punching are assumed to be 0000 and the highest available location not being used by DDT-UP for its symbol table. This address is initially 5363.

The limits may be changed for any particular zero, search, or punch command by typing LL; UL; (where LL and UL are any expressions).

A MASK for searches may also be specified. Its assumed value is 7777, but can be changed for any particular search by typing LL; UL; MASK; (where LL, UL and MASK are any expressions).

When no expression is typed preceding a ; the assumed value is taken. The values of LL, UL, MASK are reset to the assumed values when a CR is typed in or out. The user may find out the value of UL by examining location 6400.

Zeroing

Typing an expression followed by % causes DDT-UP to set the contents of locations LL through UL to the value of that expression. If no expression is typed preceding the % , a value of 0 is assumed.

Positive Searching

Typing an expression followed by > causes DDT-UP to search locations LL through UL. All locations whose contents match that expression in the bits specified by the MASK are typed out in the current mode. During the course of a search, the user may stop the search by striking any key. Note: A positive search with a mask of zero is a good way to obtain a listing.

Negative Searching

Typing an expression followed by < causes DDT-UP to search locations LL through UL. All locations whose contents do not match that expression in the bits specified by the MASK are typed out in the current mode. During the course of a search, the user may stop the search by striking any key.

Punch CBL Tape

Typing ~~TAPE~~ (ctrl T) causes leader (200 code) to be punched.

Typing TAPE (ctrl R) causes trailer (000 code) to be punched.

Preparing CBL Tape

1. Turn on the punch.
2. Type ~~TAPE~~ (ctrl T), leader is punched.
3. Turn off the punch.
4. Type in appropriate limits (MASK is ignored).
5. Turn on the punch.
6. Type ALT MODE (the key is on the left).
7. A CBL block is punched from LL through UL. While the block is being punched, the accumulator lights indicate the location being punched.
8. If all punching of blocks is complete, go to step 9; otherwise turn off the punch and repeat steps 4-7 any number of times.
9. Type TAPE (ctrl R), trailer is punched.
10. Turn off the punch.
11. DDT-UP is now waiting for type-in as if the carriage were at the beginning of a new line. In order to maintain a readable listing, a CR may be typed.

Read CBL Tape

- (1) Place the CBL tape in the reader.
- (2) Start the reader. As soon as DDT-UP recognizes leader code, it removes the breakpoint assignment and transfers control to location 7777 where it is assumed will be found a loader for reading the tape.
- (3) At the end of the tape, or when a checksum error is detected, the loader halts with usual checksum indication in the accumulator.
- (4) Turn off the reader.
- (5) Restart DDT-UP at 7000.

Reading Symbol Table into DDT-UP

A symbol table punched by SYMTAB is actually a CBL tape which includes a symbol table built down from location 5363. The tape also includes new contents of locations 6400 and 6401. Such a symbol table tape can be read into DDT-UP as a standard CBL tape. After the symbol table has been read, the user should check the new contents of location 6400 which indicates his new UL.

Punching Symbol Table

The symbol table can be punched out in CBL format, so that it can later be read back into DDT-UP. In order to find the lower end of the symbol table examine location 6400. Let x be the contents of 6400.

The following two areas must be punched:

- a) $x + 1$ through 5363
- b) 6400 and 6401

Location 6400 contains the highest available location not being used by DDT-UP for its symbol table. Location 6401 contains the two's complement of the number of symbols in the symbol table.

Define Symbol

Typing a symbol followed by `,` causes DDT-UP to define that symbol as `*`. The assumed value of UL is decreased by 4.

Kill Single Symbol or Symbol Table

Typing a symbol followed by `(` causes DDT-UP to kill the definition of that symbol. The assumed value of UL is unaffected.

Typing `(` alone causes DDT-UP to kill the current symbol table except for the initially defined PDP-8 mnemonics. The assumed value of UL is reset to 5363.

Running Programs

Typing an expression followed by `'` causes DDT-UP to:

- (1) set up a breakpoint if one was specified.
- (2) set the link and accumulator as they were the last time the debugger was entered, and clear the Teletype output flag.*
- (3) jump to the location specified by the expression preceding the `'`.

* If the user wishes to leave DDT-UP with the Teletype output flag on, he may alter location 5724, which normally contains TCF. Through DDT-UP itself, the user may set the contents of this location to NOP.

Breakpoint Assignment

Typing an expression followed by " causes DDT-UP to assign a breakpoint at the location specified by the expression. If no expression precedes the " , any breakpoint assignment is removed. A breakpoint cannot be assigned at location 0000. Only one breakpoint may be assigned at a time, but it may be changed, even before proceeding back to the program.

Since proceeds from an auto-indexing instruction or a JMS instruction are simulated by DDT-UP, there are no restrictions on breakpoint placement.

The breakpoint instruction is JMP* 5 (5405). It must not be inserted by the user by location modification at any time.

When a breakpoint trap occurs, DDT-UP turns off the program interrupt system, saves the link and accumulator, and types out the location of the break followed by) followed by the contents of the accumulator as an octal number.

Proceed

Typing a ! causes DDT-UP to clear the Teletype output flag*, restore the link and accumulator, perform the instruction at the last breakpoint location which caused a trap, and then proceed from there.

If an expression is typed preceding the ! , automatic proceeds are generated by DDT-UP for the number of times equal to the value of that expression before a breakpoint trap causes the debugger to regain control. The Teletype output flag and the program interrupt system are preserved during automatic proceeds.

Accumulator and Link

The contents of the saved accumulator for the user's program may be examined by typing @ to DDT-UP.

Typing an expression followed by @ causes DDT-UP to set the contents of the saved accumulator to the value of that expression.

Location 5600 is where the LINK is saved. This location may be examined by the user. The user may also set it to 0000 or 0001 to respectively clear or set the link. The user should not set the contents of location 5600 to anything other than 0000 or 0001.

* Same as footnote on p. 6.

Initial DDT-UP Symbol Table

The initial symbol table occupies locations 5364 through 5577 and includes the following symbols.

<u>Symbol</u>	<u>Value (octal)</u>	<u>Symbol</u>	<u>Value (octal)</u>
HLT	7402	RAR	7010
SKP	7410	CML	7020
GLK	7204	CMA	7040
STL	7120	CLL	7100
LAS	7604	CLA	7200
CIA	7041	NOP	7000
TLS	6046	IOT	6000
TPC	6044	OPR	7000
TCF	6042		
TSF	6041		
KRB	6036		
KRS	6034		
KCC	6032		
KSF	6031		
IOF	6002		
ION	6001		
OSR	7404		
SZL	7430		
SNL	7420		
SNA	7450		
SPA	7510		
SZA	7440		
SMA	7500		
IAC	7001		
RTL	7006		
RTR	7012		
RAL	7004		

DDT-UP QUICK REFERENCE

+	Two's Complement PLUS
-	Two's Complement MINUS
SPACE,&	Inclusive OR
RUBOUT,?, Undefined Symbol	Ignore current expression
Illegal Character	Bell rings, ignore character

<u>Mode</u>	<u>Equivalence</u>	<u>Examination</u>
instruction	←	/
symbolic	\$:
octal	=	[(shift K)
BCD	\ (shift L)] (shift M)
)	Take as BCD	
#	Last expression typed in or out	
*	Current location and Indirect Addressing	
CR	Modify open location (if one)	
↑	Like CR, then open *-1	
LF	Like CR, then open *+1	
;	Separator for LL; UL; MASK;	
%	Zero or Set Memory between LL, UL	
<	Negative Search between LL, UL	
>	Postive Search between LL, UL	
TAPE (ctrl T)	Punch Leader	
TAPE (ctrl R)	Punch Trailer	
ALT MODE	Punch Block between LL, UL	
Leader (200)	Remove breakpoint and read tape	
,	Define symbol as *	
(Kill Single Symbol or Symbol Table	
'	Go	
"	Breakpoint	
!	Proceed	
@	Accumulator	
ctrl O (letter)	Set mode to Octal	
ctrl S	Set mode to Symbolic	

