

**DESK CALCULATOR
PROGRAMMING
MANUAL**

PDP-6

**PDP-6 PROGRAMMING MANUAL
DESK CALCULATOR**

INTRODUCTION

The Desk Calculator program improves man-machine communication by giving the computer user direct access to basic mathematical functions within the PDP-6 subroutine library. By means of the PDP-6 multi-user station, the operator is able to enter arguments, request specific functions, and obtain resultants at electronic speeds. No complex programming rules need be learned, and no involved operational procedures need be followed. Some familiarity with modern programming systems is helpful, however, to realize the full range of capabilities inherent in Desk Calculator.

The Desk Calculator program also incorporates the macro operations programming aid. By the use of macro operations, functions not contained in the normal repertoire can be represented by a single mnemonic symbol. The macro feature also includes conditional branching capabilities, so that subroutines requiring testing and decision-making can be implemented.

OPERATING INFORMATION

The Desk Calculator program is brought from the system tape, stored in memory, and initialized by the following control statements, typed on the teletypewriter:

```
IJOB  
(Message)  
CORE 2  
GET SYS DESK  
(Message)  
START
```

where the number 2 represents the core memory space required by the 2,000-word program. The number of significant figures required may be set by a statement of the following form:

```
$FN
```

where N is any number between 0 and 7.

For example, to obtain the sine in radians of $\pi/4$ to five significant figures, the following is typed:

```
$F5  
SIN(3.14159/4)←
```

The ← character is a demand for output. The ALT MODE key is depressed to complete the input command. The program evaluates the typed expression and types the answer, so that the second line becomes

$$\text{SIN}(3.14159/4) \leftarrow 0.70711$$

Alternatively, the carriage return function could have been selected to complete the input command. When this is done, the resultant appears on the next line.

Other functions of integers can be obtained in a similar way. Table 1 is a list of all functions contained in the basic Desk Calculator program. Following is a list of the available arithmetic operators:

<u>Symbol</u>	<u>Operation</u>
+	add
-	subtract
*	multiply
/	divide
↑	raise to the power
()	subexpression grouping parentheses
=	Replacement operator. The expression on the left is stored into the variable on the right. Multiple replacements may be accomplished by commands of the form (exp) = a, b, c,

TABLE 1 LIST OF FUNCTIONS

Function	Description
ATN	arctangent in radians
COS	cosine in radians
CSD	cosine in degrees
EXP	exponential (e^x)
LOG	natural logarithm ($\text{LOG}_e X$)
SIN	sine in radians
SND	sine in degrees
XNT	integer part (i.e., truncate floating-point number so that only a floating-point integer remains)



Pseudo-Operations

Pseudo-operations direct the program to perform certain utility functions, and are so-called because of their functional similarity to basic machine-language operations. Pseudo-operations provide for defining macro-operations, deletion of resultants and functions, and output format specification.

A conceptual accumulator register is used that serves a purpose analogous to the hardware accumulator register; that is, resultants are placed in the conceptual accumulator for reference or modification by sub-sequent operations. Hence, a clear-accumulator pseudo-operation (\$C) has been included to provide for disposing of unneeded resultants.

Single-precision, floating-point arithmetic is used. By means of the \$FN pseudo-operation, up to 7-place accuracy can be specified. However, the propagation of round-off errors caused by nesting and similar iterative procedures may in some cases cause a loss of significance in the seventh place.

Pseudo-operations are listed in Table 2. Note that pseudo-operations always begin with the \$ symbol.

TABLE 2 PSEUDO-OPERATIONS

Symbol	Operation
\$C	Clear the accumulator
\$D	Define macro operation
\$FN	Round output to N significant figures ($0 \leq N \leq 7$)
\$I	Round output to nearest integer (same as \$F0)
\$K	Delete the function specified by the user. If no function is specified, delete all user functions, and set all variables to 1.0.
\$L	Output line (carriage-return followed by a line-feed). Used in macro operations.
\$R	Secondary exit from a macro-operation.
\$T	Output tab. Used in macro operations.

Variables

Variables are represented by a single letter (A-Z). Strictly speaking, variables represent memory locations, the contents of which may vary.

Comments

Comments are delineated by quotation marks (" "). Everything between the quotes is regarded by the program as a comment.

Macro Operations

Macro operations or "macros" enable the programmer to generate useful extensions to the normal symbolic repertoire of Desk Calculator. Macros are defined by the \$D pseudo-operation. The ; character delimits both the macro mnemonic and the instructions comprising the macro-operation. Hence, macros are generated by instructions of the form

```
$DMNE;INS;
```

where MNE is the macro name or mnemonic, and INS represents the series of instructions within the macro.

As an example, suppose we wish to obtain a macro that will furnish several functions of a variable, X.

We type the following statements to define the required macro:

```
$DLOP;  
X!SND(X)!CSD(X)!SND(X)2+CSD(X)2←;
```

The ! character causes the PDP-6 to output the expression value, followed by a tab. The ← character causes output of the expression value, followed by a carriage return. The accumulator is cleared after either operation. The program makes a normal exit at the end of the macro.

The macro can now be called by

```
LOP
```

and the program will respond by typing the values X, SIN X, COS X, and $(\text{SIN}^2 X + \text{COS}^2 X)$.

Labels Within a Macro - Labels for symbolic memory locations are one to three digits in length, and must be followed by a colon. Labels must be the first entry on a line.

Formatting - Formatting of the macro operation output is accomplished by the ! and ← characters described above, and by the pseudo-operation's \$L, \$T, \$FN, and \$I, described in Table 2. Text may be output by enclosing the character string within quotation marks.

Arguments Within a Macro - Macros may contain up to nine arguments. Thus, calling statements will be of the general form

$$\text{MNE}(A_1, A_2, \dots, A_N)$$

where MNE is the macro mnemonic, $A_1 \dots A_N$ are the input arguments, and $N \leq 9$. Within the macro each argument is referenced by the expression $\#N(1 \leq N \leq 9)$.

Transfers Within a Macro - Several conditional transfer instructions (Table 3) are available to facilitate coding of functions and subroutines. Except for the TA and STP instructions, the first argument of a conditional transfer instruction is an expression, and the second is a label. For TA, the only argument required is a label. For STP, the first argument is a variable, and the second is a label.

An example of a macro using a conditional transfer is as follows:

```
$DABS;TGE(#1,1)$C-#1$R
1:#1;
```

In the macro above, ABS is defined as a transfer to label 1 if the first input argument of ABS is greater than or equal to zero (TGE instruction). If the transfer is made, the first argument is loaded into the accumulator and a normal exit from the macro is made. If no transfer is made, the accumulator is cleared, the first argument is complemented, and an alternate exit is selected.

TABLE 3 TRANSFER INSTRUCTIONS

Mnemonic	Description
TA	Transfer unconditional
TN	Transfer if not zero
TE	Transfer if equal to zero
TG	Transfer if greater than zero
TGE	Transfer if greater than or equal to zero
TL	Transfer if less than zero
TLE	Transfer if less than or equal to zero
STP	Subtract one from first argument, and transfer if the resultant is greater than zero

Among the uses of macro operations is the generation of tabular lists of functions. Suppose, for example, we wish to generate a table of sines and cosines. The general form of the calling statement would be

$$\text{SYM}(I, T, S)$$

where I is the initial value of the argument for which trigonometric functions are to be generated, T is the terminal value, and S is the amount by which the argument is increased before each successive pair of functions is generated. This type of calling statement may be implemented by the following macro operation (the lines are numbered for reference):

<u>Line No.</u>	
1.	\$DSYM
2.	"X SINX COSX \$L
3.	"#1=X
4.	#2=Y
5.	1:\$F1X!\$F5SND(X)!CSD(X)!
6.	X+#3=X
7.	TGE(Y-X, 1)\$L;

The macro name is set in line one, and tabular heading data is generated in line two. In lines three and four, the first two input arguments are assigned the symbolic designations X and Y. The fifth line prints the argument X with one-place accuracy, and generates and prints the sine and cosine of X with five-place accuracy.

The sixth line increments the symbolic argument X by the value of the third input argument; the resultant sum becomes the new argument. The seventh line effects a transfer to line 5 to compute functions for the new argument. When X equals or exceeds Y, line 7 effects a normal exit from the macro.

Suppose that the above macro has been coded. Typing the following statement,

$$\text{TAB}(10, 60, 10)$$

followed by a carriage return, causes the program to generate the following printout:

X	SIN(X)	COS(X)
10.0	0.17365	0.98481
20.0	0.34202	0.93969
30.0	0.50000	0.86603
40.0	0.64279	0.76604
50.0	0.76604	0.64279
60.0	0.86603	0.50000

Change Notice 1

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To further increase the flexibility of the Desk Calculator, the following features have been added:

1. ' (single quote) will cause the accumulator to be output, with no tab or carriage return following.
2. \$P,\$G - PUT-GET - Save and restore variables on the pushdown list. The form is:

```
⋮  
$PX,Y,Z  
⋮  
$GZ,Y,X  
⋮
```

Note that the list in the GET is reversed from that in PUT. The arguments of PUT and GET must be variables - not expressions. There is provision for storage of 20 variables on the list.

3. On page 6 in the manual, in the first chart, opposite Line No. 2: change "X SINX COSX \$L to read
"X SIN(X) COS(X)

digital

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