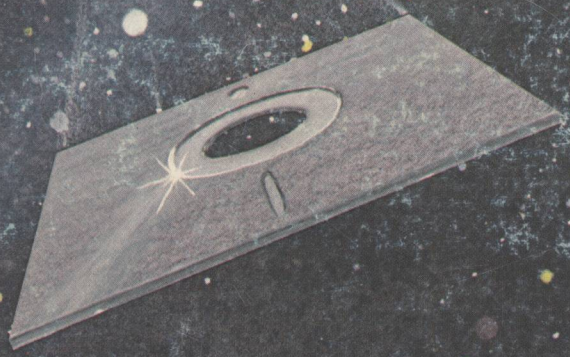
Best of INTERFACE AGE

VOLUME I SOFTWARE IN BASIC

Edited by carl d. warren



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Best of Interface Age

Volume 1: Software in BASIC

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Volume 1: Software in BASIC

Preface

Several months ago, it became apparent that we should give serious thought to creating a "best of" series from the pages of *Interface Age*. The idea seemed like it would not present a major problem at first, until we looked at the mountain of material we had available. The quantity wasn't the only problem. The decision had to be made on what was best, so it could be included in the reprint series.

After careful consideration, with close attention being paid to readers' letters, the decision was made to create a "best of" series of *Interface Age* Classics. What this meant was that rather than to create a huge, difficult to use book of just about everything, we are printing the classic software pieces and the ones that many readers said they would like to see.

The four reprinted articles that you find in this volume are those classics. Furthermore, they represent several different programming techniques. At the same time, they provide the reader with some of the most useful software ever created.

Chapter four, "The Great Experiment," offers the one piece of software that has been requested more than any other: the complete source listing of Uiterwyk's 4K BASIC. It is an absolute classic. The source code was released into the public domain by Mr. Uiterwyk for this software volume, so students of software could achieve maximum benefit from its use. For this, we at *Interface Age* are extremely grateful.

My staff and I are quite convinced that everyone who makes use of this first volume will find it invaluable in making better use of their systems.

Volume 2 of this series is made up of additional general purpose software from some of the *Interface Age* authors you have enjoyed over the past few years. Volumes 3 and 4 are dedicated specifically toward the small businessman. These two volumes contain more business software than any book currently available today.

To round out this current "best of" series, Volume 5, *Best of Interface Age—Things to Think About*, contains those articles for the futuristic thinker and gadgeteer. This volume contains reprints from Roger Garret's famous "Inventor's Sketchpad." Also included are short and useful software tips, along with some handy hardware articles.

Interface Age has always been known as the leader in the publication of important and useful software and ideas. We feel that the publication of this "best of" series will further enhance our leadership and provide you with hundreds of hours of enjoyment.

carl warren
editor-in-chief

Acknowledgment

When a reprint series is created, it is of utmost importance to thank the authors whose works are being reprinted. We gladly extend our appreciation to them. We also thank all those authors that contributed articles over the past forty-plus issues, and the readers that have made us such a success.

Robert S. Jones
Publisher

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Chapter 1

Lawrence Livermore Laboratories 8080 Basic Interpreter

by Jerry Barber, Royce Eckard John Dickenson, David Mead and E. R. Fisher

The year 1976 saw a number of accomplishments to the microcomputer world, which was still very much in its infancy. The most important developments were with BASIC interpreters being made available to the micro user.

One such BASIC, was the 8080 version developed at the University of Idaho by John Dickenson, Jerry Barber, and John Teeter; under a contract with the Lawrence Livermore Laboratory. The floating point package was developed by David Mead, modified by Hal Brand and Frank Olken.

The entire project, including the course listing of the interpreter was documented in the December 76, January 77, February 77, and March 77 issues of Interface Age magazine.

Because BASIC is still considered the most important language in the microcomputer industry, and also due to the continuing interest in the LLL version, we have re-published it here in its entirety.

STORAGE REQUIREMENTS

The BASIC interpreter consists of a 5K-byte-PROM resident interpreter used for program generation and debug was configured to operate with the MCS-8080 microprocessor.

The goal in developing the 8080 BASIC was to provide a high-level, easy-to-use conversational language for performing both control and computation functions in the MCS-8080 microprocessor. To minimize system memory size and cost, the interpreter was constrained to fit

into 5K bytes. It was necessary, therefore, to limit the commands to those considered the most useful in microprocessor applications.

MATH OPERATOR EXECUTION TIMES

Average execution times of the four basic math operators are as follows:

Operation	Execution time on 8080 (m sec)
ADD	2.4 m sec
SUBTRACT	2.4 m sec
MULTIPLY	5.4 m sec
DIVIDE	7.0 m sec

BASIC INTERPRETER LANGUAGE GRAMMAR

COMMANDS—Six BASIC interpreter commands are provided. These commands are:

RUN	Begins program execution
SCR	Clears program from memory
LIST	Lists ASCII program in memory
PLST	Punches paper-tape copy of program
PTAPE	Reads paper-tape copy of program using high-speed reader
CNTRL S	Interrupts program during execution

The LIST and PLST commands can be followed by one or two line numbers to indicate that only a part of the program is to be listed. If one line number follows the command, the program is listed from that line number to the end of the program. If two line numbers (separated by a comma) follow the command, the listing begins at the first line number and ends at the second.

When a command is completed, READY will be typed on the teletype. Once initialized by a command, a process will normally go to completion. However, if you wish to interrupt an executing program or a listing, simply strike CNTRL S and the process will terminate and a READY message will be typed.

STATEMENTS—Each statement line begins with a line number, which must be an integer between 0 and 32767. Statements can be entered in any order, but they will be executed in numerical order. All blanks are ignored. The following types of statements are allowed:

REM—Indicates a remark (comment). The system deletes blanks from all character strings that are not enclosed in quotes ("). Therefore, it is suggested that characters following the REM key word be enclosed in quotes.

END—Indicates the end of a program. The program stops when it gets to the END statement. All programs must end with END.

STOP—Stops the program. This statement is used when the program needs to be stopped other than at the end of the program text.

GOTO—Transfers program control to specified statement line number. This statement is used to loop or jump unconditionally within a program. Program execution continues from new statement.

DIM—Declares an array. Only one-dimensional arrays with an integer constant number of elements are allowed. An array with N elements uses indexes 0 and N-1. All array locations are set to zero. No check is made on subscripts to ensure that they are within the declared array. An array variable must be a single letter.

LET—Indicates an assignment statement (Addition, subtraction, multiplication, division, or special function may be used). The LET statement is used to assign a value to a variable. Non-array variables can be either a single letter or a letter followed by a digit. It is possible to have an array and a non-array variable with the same name. The general form of the LET statement is:

line number LET identifier = expression,

where *identifier* is either a subscripted array element or a non-array variable or function and *expression* is a unary or binary expression. The expression will be one of the following ten types:

variable
– variable
variable + variable
variable – variable
– variable + variable
– variable – variable
variable * variable
– variable * variable
variable / variable
– variable / variable,

where *variable* is an identifier, function, or number. The subscript of an array can also be an expression.

IF—Condition statement which transfers to specified line number statement if the condition of the expression is met. It has the form: line number IF expression relation expression THEN transfer line number. The possible relations are:

Equal	=
Greater than	>
Less than	<
Greater than or equal	>= =<
Less than or equal	<= =<
Not equal	<> ><

If the relation between the two expressions is true then the program transfers to the line number, otherwise it continues sequentially.

INPUT—This command allows numerical data to be input via the teletype. The general form is:

Line number INPUT identifier list,

where an *identifier list* is a sequence of identifiers separated by commas. There is no comma after the last identifier so, if only one identifier is present, no comma is needed. When an INPUT statement is executed, a colon (:) is output to the teletype to indicate that data are expected. The data are entered as numbers separated by commas. If fewer data are entered than expected, another colon is output to the teletype, indicating again that data are expected. For example, where

50 INPUT I,J,K,P

is executed, a colon is output to the teletype. Then, if only 3 numerical values are entered, another colon will be output to indicate that more data are expected; e.g.,

:4,4,6.2 C/R
:10.3 C/R

where C/R is the carriage-return key. If an error is made in the input-data line, an error message is issued and the entire line of data must be reentered. If, for the above example,

:4,4,6M2,10.3 C/R

is entered, the system will respond:

INPUT ERROR, TRY AGAIN
:

At this time, the proper response would be

4,4,6.2,10.3 C/R.

PRINT—This command allows numerical data and character strings to be printed on the teletype. Two types of print items are legal in the print statement: character strings enclosed in quotes (") and expressions. These items are separated by either a comma or a semicolon. If print items are separated by a comma, a skip occurs to the next pre-formatted field before printing of the item following the comma begins. The pre-formatted fields begin at columns 1, 14, 27, 40, and 52. If print items are separated by a semicolon, no skip occurs. If a semicolon or comma is the last character on a print statement line, the appropriate formatting occurs and the carriage-return-line feed is suppressed. A print statement of the form

50 PRINT

will generate a carriage-return-line feed. Thus the two lines below

50 PRINT "INPUT A NUMBER";
60 INPUT A

will result in the following output:

INPUT A NUMBER:

FOR—Causes program to iterate through a loop a designated number of times.

NEXT—Signals end of loop at which point the computer adds the step value to the variable and checks to see if the variable is still less than the terminal value.

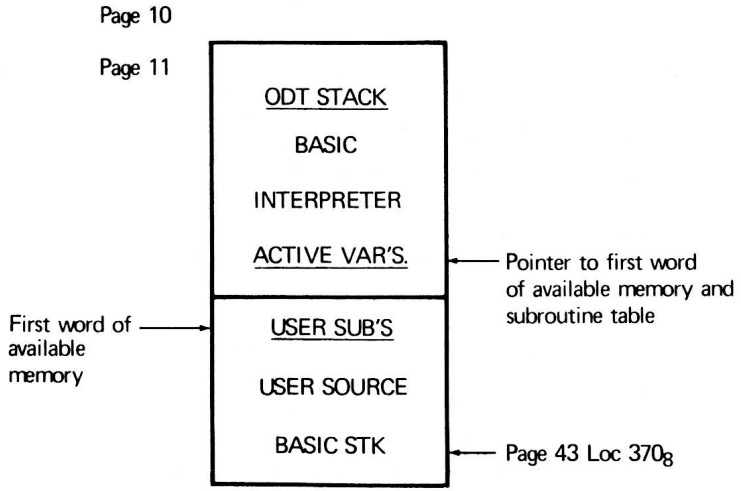
GOSUB—Transfer control to a subroutine that begins at specified line number.

RETURN—Returns control to the next sequential line after the last GOSUB statement executed. A return statement executed before GOSUB is equivalent to a STOP statement.

CALL—Calls user-written assembly-language routines of the form

CALL (N,A,B,. . .),

where N is a subroutine number from 0-254 and A, B,. . . are parameters. The parameters can be constants, variables, or expressions. However, if variables and constants or expressions are inter-mixed, all variables should have been referenced before the CALL statement. Otherwise, the space reserved for newly referenced variables may overwrite the results of constants and expressions. A memory map of one configuration of the system is shown below.



The subroutine table contains 3-byte entries for each subroutine. The table directly follows the pointer to the first word of available memory (FWAM) and must end with a octal 377. A sample table and its subroutines is shown below:

```
ORG 16612Q
DWSUBEND        ;Define FWAM
DB 1            ;Subroutine #1
DW SUB1         ;Starting add of subroutine
                #1
DB 4            ;Subroutine #4
```

```
DW SUB4         ;Starting add of subroutine
                #4
DB 5            ;Subroutine #5
DW SUB5         ;Starting add of subroutine
                #5
DB 2            ;Subroutine #2
DB SUB2         ;etc.
DB 377Q         ;end of subroutine table
SUB1:           ;Subroutine #1
     RET
SUB5:           ;Subroutine #5
     RET
     •
     •
     •
     RET        ;Retain last subroutine
SUBEND EQU$     ;FWAM
```

Addresses to passed parameters are stored on the stack. The user must know how many parameters were passed to the subroutine. These must be taken off the stack before RET is executed. Addresses are stored last parameter first on the stack. Thus, on entry to a subroutine, the first POP instruction will recover the address to the last parameter in the call list. The next will recover the next to last, etc.

Each scalar variable passed results in the address to the first byte of a four-byte block of memory. Each array element passes the address to the first byte of a (N-M) × four-byte memory block, where N is the number of elements given the array in the DIM STMT and M is the array subscript in the CALL STMT.

For passed parameters to be handled in expressions within BASIC, they must be in the proper floating-point format.

FUNCTIONS—Two special functions not found in most BASIC codes are available to input or output data through Intel 8080 port numbers. These functions are;

GET (X) = READ 8080 INPUT PORT X.
PUT (Y) = OUTPUT A BYTE OF DATA TO OUTPUT PORT Y.

The function GET allows input from a port and the function PUT allows output to a port. Their general forms are:

GET (expression).
PUT (expression).

The function GET may appear in statements in a position that implies that a numerical value is used. The function PUT may appear in

statements in a position that implies that a numerical value will be stored or saved. This is because GET inputs a number and PUT outputs a number. For example, while

LET PUT(I) = GET(J) is valid

LET GET(I) = PUT(J) is invalid.

These functions send or receive one byte of data, which in BASIC is treated as a number from 0 to 255.

VARIABLES—Single characters A→Z

Single character followed by a signal decimal digit

NUMBERS—Numbers in a program statement or input via the teletype are handled with a floating-point package provided by LLL. Numbers can have any of the following forms:

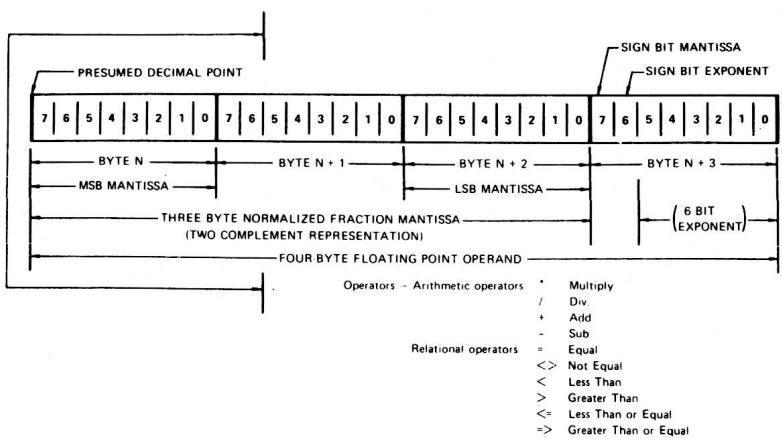
4	±4.	.123
4.	±4.0	±.123
4.0	1.23	0.123
±4	±1.23	±0.123

and the user may add an exponent to any of the above forms using the letter E to indicate powers of 10. The forms of the exponent are:

E±1	E±15
E 1	E 15
E 1	E 15

The numbers are stored with seven-digit accuracy; therefore, seven significant figures can be entered. The smallest and largest numbers are ±2.71051E-20 and ±9.22337E18.

Floating point numbers are expressed as a 32 bit operand consisting of a 24 bit normalized fractional mantissa in standard two's complement representation and a 6 bit exponent also is standard two's complement representation with a range of −64 to +63. The exponent byte also includes the exponent sign bit and mantissa sign bit. The floating point number format is as shown in the following:



INTERPRETER OPERATION

INITIALIZATION—The BASIC interpreter is presently configured so that it is located in memory pages 11_8 to 34_8. The starting address is page 17_8, location 0. This address begins an initialization sequence that allows the user to begin with a clear memory. However, to avoid the initialization sequence, a second starting address—page 17_8 to 34_8—can be used. This starting address is used if the user wishes to retain any program that might exist in memory.

Once started the interpreter responds with READY.

INPUT LINE FORMAT

Each line entered is terminated with the carriage-return key. The line-feed key is ignored. Carriage-return automatically step terminal to next line and waits for next line statement number input. Statements can be entered in any order, but they will be executed in numerical order. All blanks outside of quotation marks are ignored by the interpreter. Up to 72 characters may be entered/line.

INPUT LINE EDITING—A program can be edited by using the line numbers to insert or delete statements. Typing a line number and then typing a carriage return causes the statement at that line number to be deleted. Since the statements can be entered in any order, a statement can be inserted between two existing statements by giving it a line number between the two existing statement line numbers. To replace a statement, the new statement should have the same line number as the old statement.

It is possible to correct errors on a line being entered by either deleting the entire line or by deleting one or more characters on the line. A character is deleted with either the rubout key or the shift/O key. Several characters can be deleted by using the rubout key several times in succession. Character deletion is, in effect, a logical backspace. To delete the line you are currently typing, use the CNTRL/Y key.

BASIC PROGRAM EXECUTION—Entering a RUN command, after a BASIC program has been entered into the microcomputer, will cause the current program to begin execution at the first statement number. RUN always begins at the lowest statement number.

ERROR MESSAGES—If an unrecognizable command is entered, the word WHAT? is printed on the teletype. Simply retype the command. It may also have been caused by a missing line number on a BASIC statement, in which case you should retype the statement with a line number.

During program execution and whenever new lines are added to the program, a test is made to see if there is sufficient memory. If the memory is full, MEMORY FULL is printed on the teletype. At this point, you should enter one of the single digits below to indicate what you wish to do:

Number Entered	Meaning
0	(RUN) runs
0	(RUN) runs the program in memory
1	(PLST) outputs program in memory to paper tape punch
2	(LIST) lists program in memory
3	(SCR) erases program in memory
4	none of the above (will cause WHAT? to be printed out on the teletype).

To help you select the best alternative, a brief description of how the statements are manipulated in memory will be helpful. All lines entered as program are stored in memory. If lines are deleted or replaced, the originals still remain in memory. Thus, it is possible, if a great deal of line editing has been done, to have a significant portion of memory taken up with unused statements. If a MEMORY FULL message is obtained in these circumstances, then the best thing to do is punch a tape of the program (entering number 1), then erase the program memory with a SCR command (or a number 3, if memory is too full to accept commands), and then re-enter your program using the high-speed paper-tape reader with the PTAPE command.

If an error is encountered while executing a program, an error message is typed out that indicates an error number and the line number in which the error occurred. These numbered error messages are as follows:

Error Number	Error Message
1	Program has no END statement
2	Unrecognizable keyword at beginning of statement
3	Source statements exist after END statement
4	Designation line number is improperly formed in a GOTO, GOSUB, or IF statement
5	Designation line number in a GOTO, GOSUB, or IF statement does not exist
6	Unexpected character
7	Unfinished statement
8	Illegally formed expression
9	Error in floating-point conversion
10	Illegal use of a function
11	Duplicate array definition
12	An array is referenced before it is defined
13	Error in the floating-point-to-integer routine, Number is too big
14	Invalid relation in an IF statement