5: A high level language in 3/4 K!
M5 SYSTEM—AN INTERPRETER FOR THE NASCOM ON

Designed and Implemented
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0.0 The M5 Language

0.1 Nascom Implementation

The M5 interpreter was designed for implementation on small 8 bit microcomputers and the Nascom one standard system was an ideal choice because of its popularity and use of a fairly powerful processor (the Z80).

With only about 940 bytes available to the user, the language had to be compact enough to write decent programs in a small space, and also have a small interpreter to leave the maximum amount of spare memory. A simple editor was almost essential if programs of over about 50 bytes were to be written and debugged easily, and this required about 100 bytes.

The editor, interpreter and command mode are closely linked—for example, program variables are maintained over edits, and resets, and the editor will set up its cursor to inform the user where an error occured.

A compact M5 program can be difficult to follow initially, so error routines which give the exact location and type of a run-time error are included, despite the penalty in RAM usage. (Execution speed is unaffected by error checking).

M5 is a very fast interpreter, although loops are not as fast as in machine code because each loop involves a small search. A well written M5 program will carry out general calculations at about 1/3-1/5 of the speed of machine code. (M5 programs are usually much faster to write and debug of course!)

The user may write programs of about 230 bytes in length—quite large in M5. Overlarge programs may cause trouble when entered, but the most likely indication of an overflow is a lot of garbage appearing on the end of the program when it is listed.

0.2 Introduction

The M5 system is entered by typing EC60 when M5 has been entered into user RAM. The prompt 'M5:' should then appear at the bottom of the screen, indicating that the system is in the command mode. Commands which may be entered now are:

1 Input a new program and destroy the previous one. System responds with a newline and waits for the user to enter a program. Input is terminated by a semi-colon, which returns the user to the command made.

L List the program currently in store and return to command mode.

R Run the current program starting at the first symbol, after printing a newline.

E Edit the current program, inserting the character pointer at the place the last instruction was executed—or where an error was found.
(See section on editor.)

RS RESET the Nascom. This will cause a return to Nasbug. However, the current program and value of X will be maintained ready for typing EC60 to resume programming. RESET must also be used to star a looping program.

0.3 Initialisation

When entering M5 for the first time after loading it, it is best to initialise the user work area by entering and running a null program. This is done as follows: (Underlined characters are typed by the system.)

M5:Input
: (I.E. Terminate input after entering nothing!!!)

M5:R (Null program simply results in a carriage return.)

M5: (System is now initialised.)

0.4 Other commands

M5 will respond with a new prompt to any unknown command letter.

0.5 Errors on input

A backspace will delete the last character only when in input mode. It may seem misleading if used to backspace up a line. (Try it and see!)

Backspaces can be inserted into a string in the program by using the INSERT command in EDIT mode.
Semicolons are illegal characters inside an M5 program.
Shift-Backspace is a legal character in strings.

1.0 BASIC M5 LANGUAGE PRINCIPLES

1.1.0 M5 Arithmetic

The basic elements handled in standard M5 are 16 bit unsigned integers, which are adequate for most games and simple simulation or number manipulation. Numbers are in the range 0 - 65535 (decimal) and are modulo 65536 so 65536 seems the same as zero to the language.

Operators permitted in M5 are:

* (multiply) / (divide) + (add) – (subtract) # (-1) & (+1)

the last two are included for faster execution if required, and for compact programming of loop control. (See later).

1.1.1 The Stack

An important aspect of M5 which is quite powerful once it is understood, is its stack based (Reverse polish) expression analysis. This system requires no parentheses and it can be used to evaluate arbitrary expressions quickly. The M5 algebraic system is similar to that found on some calculators and the analogy with a calculator is used in these notes.

1.1.2 The Current Value

On a pocket calculator, the idea of a current value is easy to understand as it appears on the display and is often called "x". In M5 there is also a current value (called "X"), and it is altered only in the following circumstances:

1) If a number appears in the program (not in a string) x takes its value.
2) On encountering an identifier A-7 x takes the value stored there.
3) On encountering a ? (not after =) x takes its value from the keyboard.
4) After a diadic operator (/ - + *) x becomes the result.
5) If x is incremented or decremented (using & or #).

1.1.3 Variables

As in most other languages, M5 has variables A-7 and a special one @.
One of these variables becomes current by simply quoting it in the program.
(point 2 above).
X may be stored in asvariable by simply using =k where k is a variable name.
If = ? is used, the current value (x) is displayed as a decimal number on the screen. (This is how numbers are output in M5).

EXAMPLES (These are all legal M5 programs–Try if unsure!)

(i)	A	What is in location A is now also in x (the current value).
(ii)	ABC	x takes on the values in A then B then C and keeps the value C.

(iii) 23 x becomes 23.
(iv) 23A x becomes 23 , then x becomes A (i ė. the number in A).
(v) 23 456 x becomes 23 and then x becomes 456.
(vi) A=B x becomes A , then this value is stored in B.
(vii) A=B=C=D x becomes A , then this value is put into B , C and D.
(viii) A=? D=? x becomes A and this is displayed, then x becomes B and is displayed.
(ix) =?=A x what is in x (left from last program) is displayed and put in A).

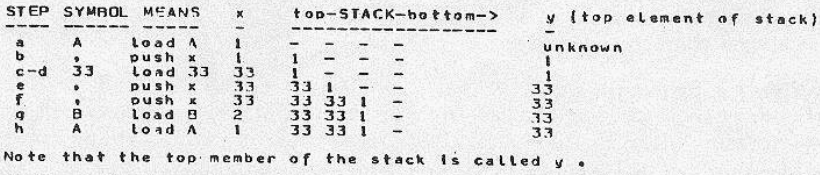
N.B. If you want to check what is going on, put the characters: =? in your program and x at these points will be printed.
For neatness and readability use: =? “ ” which separates No’s by a space.
E.G. 23=?“ “ 1 1 1 1 1 =?” will produce: 00023 11111 as output if run.

1.1.4 Calculating

When a comma is encountered in an M5 program, the value of x is put on the top of the stack– pushing down all other members.
We can represent the stack diagramatically to show what happens.

Imagine the M5 program A,33,,BA where initially A=1 and B=2
step: abcdefgh (could have run 1=A2=3 before)

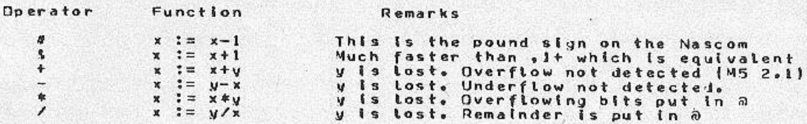
and follow it step by step:



```
STEP SYMBOL MEANS     x     top-STACK-bottom->    y (top element of stack)
---- ------ -----     -     ------------------    -
 a     A    load A    1     -   -   -   -         unknown
 b     ,    push x    1     1   -   -   -         1
 c-d  33    load 33   33    1   -   -   -         1
 e     ,    push x    33    33  1   -   -         33
 f     ,    push x    33    33  33  1   -         33
 g     B    load B    2     33  33  1   -         33
 h     A    load A    1     33  33  1   -         33
Note that the top member of the stack is called y .
```

So far, we have no means of removing items from the top of the stack. We do this by using operators such as + / * - .

The operators work on x and y and put the result in x, removing y from the stack.
Operators therefore do the following:

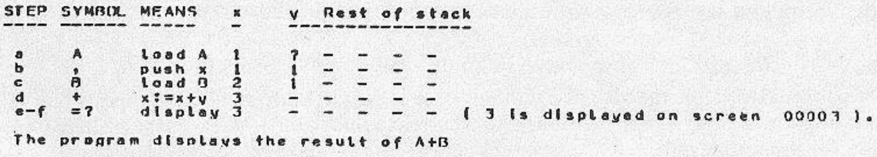


```
Operator       Function             Remarks

   #           x := x-1         This is the pound sign on the Nascom
   $           x := x+1         Much faster than ,1+ which is equivalent
   +           x := x+y         y is lost. Overflow not detected (M5 2.1)
   -           x := y-x         y is lost. Underflow not detected.
   *           x := x*y         y is lost. Overflowing bits put in @
   /           x := y/x         y is lost. Remainder is put in @
```

EXAMPLES

Program A,B+=? Initially A=1 B=2
step: abcdef

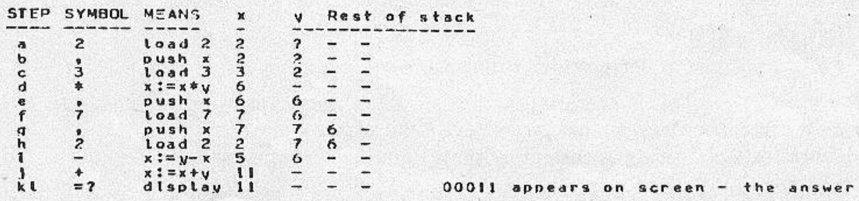


```
STEP SYMBOL MEANS     x     y  Rest of stack
---- ------ -----     -     ----------------

 a     A    load A    1     ?   -   -   -   -
 b     ,    push x    1     1   -   -   -   -
 c     B    load B    2     1   -   -   -   -
 d     +    x:=x+y    3     -   -   -   -   -
 e-f   =?   display   3     -   -   -   -   -   ( 3 is displayed on screen  00003 ).
 The program displays the result of A+B
```

Program to evaluate (2*3) + (7-2) and display it.

Program 2,3*, 7,2- + = ? i.e. add result of 2,3* to 7,2- and display.
step: abcd e fghi j kl



```
STEP SYMBOL MEANS     x     y  Rest of stack
---- ------ -----     -     ----------------
 a     2    load 2    2     ?   -   -
 b     ,    push x    2     ?   -   -
 c     3    load 3    3     2   -   -
 d     *    x:=x*y    6     -   -   -
 e     ,    push x    6     6   -   -
 f     7    load 7    7     6   -   -
 g     ,    push x    7     7   6   -
 h     2    load 2    2     7   6   -
 i     -    x:=y-x    5     6   -   -
 j     +    x:=x+y    11    -   -   -
 kl    =?   display   11    -   -   -          00011 appears on screen - the answer
```

NOTE The operators # and & only affect x and are equivalent to ,1- and ,1+ (although faster and shorter).

Imagine we want to store the result of multiplying N by M in A.

In Basic this is A=M*N
But in M5 this is M,N*=A

Here are some further examples of expressions:

```
   BASIC             M5
   =====             ==

Z=N*M*A           N,M*,A*=Z    OR   N,M,A,**=Z
Z=(N+M)*A         N,M+,A*=Z
Z=(N+M)*(A-M)     N,M+,A,M-*=Z
Z=N*N             N,*=Z
Z=N*N*N*N         N,*,*=Z   OR  N,,,***=Z     (N.B. M5 ONLY NEEDS TO GET N ONCE )
```

1.2 Getting Data In

Data in M5 is Input from the keyboard. The program requests a number from the keyboard when it encounters a LOAD ? i.e. a ? in the program, not following =.

A number is terminated by any non numeric character. Usually the user will type a space after the number and the program will continue on the same line, otherwise he will use a newline after typing the number.

EXAMPLE ? , ? * = ? will prompt for a number, then another and print the product.

1.3 String print

Any string of characters surrounded by quotes ' " ' is printed to the display exactly as written– including newlines etc.

e.g. "Input the number"
or "NEW
LINE"

N.B. A jump will find labels in a string so beware of using (in a string.

A nicer version of the program above is:

"NUMBER" ?, "TIMES BY"?*" IS "=?

A newline is produced by a newline between quotes.

1.4 Loops and jumps

A way of repeating operations is almost essential in a programming language. In M5 this is done by using using jumps and labels.

A label is represented in M5 by in where n is any symbol which can be entered at the keyboard. Examples are: (A (! (1 (.

A jump is represented by lkn where n is a symbol which matches a label, and k is a condition code indicating what condition involving x or x and y must be true for the jump to occur.

Valid condition codes are as follows:

CONDITION CODE CHARACTERS:

Character	Jump occurs if:	Comments:
U	–unconditional–	U stands for unconditional
Z	value of x is 0	7 stands for zero
N	value of x is not 0	N stands for non zero
E	x=y (top 2 on stk)	E stands for equal
X	x=y	X looks like a notequal sign
L	x = y	L stands for less than or equal
G	x = y	G stands for greater than
M	–unconditional–	M is monitor . jump to editor.

EXAMPLES of valid jump symbols are:

)UA)NI (X$)G((Z. matching labels above.

when a jump symbol is reached, the condition indicated by K is tested and if it is found to be true, a jump is made to the first occurence of a label with matching identifier symbol.

EXAMPLES:

```
(i)     2000 (A  "HELLO" #  )NA          prints out "HELLO" 2000 times.
(ii)       0 (A =?  " "  &  )NA          prints out numbers from 0 to 65535
                                         separated by spaces. (Thinks 65536=0 ).
(iii)   (A   )UA                         Loops until RESET is pressed.
(iv)    0=N (A N=? &=N . 5555 )GA        prints out numbers from 0 to 5555.
```

2.0 WRITING PROGRAMS

M5 is a powerful language when all its features are properly understood, but it can be a little confusing for the beginner. There is fortunately an easy way of generating programs which can be used until familiarity with M5 is achieved. The method is to write the program in a more standard language and then translate into M5. While this method does not exploit the valuable 'current variable' feature of M5, it will yield workable programs which are easier to follow in many ways. The program can then be optimised when it has started to work.

EXAMPLE: A Program to print a table of squares from 1 to 30.

```
BASIC                               M5

10 PRINT  "TABLE OF SQUARES"        "TABLE OF SQUARES
20 N=0                              "
                                    0=N
30 N=N+1                           (B N,1+ = N
40 PRINT N, N*N                     N=? "  " N,N*=? "
                                    "
50 IF N  =  20 GOTO 30              N , 20 )XB
60 END                              )M
```

NOTE: Newlines in output must be included between quotes in M5 programs. The numbers in M5 are not spaced on output, hence the space in the line equivalent to line 40.

The M5 produced will be completely sound and will run at about the same speed as the tiny Basic program.

If the M5 is optimised, keeping N in ''x'' as much as possible and using the free layout and the & operator, the speed will be considerably faster, perhaps 4-5 times faster than a fast tiny basic.

Optimised:

```
"TABLE OF SQUARES
" 0=N (B N&=N=? "  " ,*=? "
"N,20 )XB  )M
```

3.0 THE EDITOR

3.0 Introduction

The M5 Editor is entered by typing E when in the command mode.

The edit prompt of E: will appear when the editor is ready to accept input.

The editor will show the point where the last instruction was executed when it is entered by positioning a cursor at this location. The cursor is a shaded in square which is denoted here by a — (underline).

The cursor indicates the current position of the character pointer, and the character pointed at by the cursor appears at the top right of the screen. All manipulation of text is done relative to this cursor because there are no line numbers in M5.

The character indicating end of file in M5 is a null character which appears as a box when it is pointed at.

A hazard in the M5 interpreter is that the pointer can be moved into the actual M5 Interpreter. A Rule must therefore be: DO NOT use any Delete or insert commands unless you can see where the pointer is positioned.

3.1 Commands

To manipulate the text of a program, the user must be able to position the cursor in the required area and then operate on the text. Commands to move the pointer are as follows:

>	Move cursor forward one place.
<	Move cursor backward one place.
R	Rewind–i.e. move cursor to the start of the file.
N	Move the cursor to the start of the next time (stop at end of prog.)

These commands may be repeated and if followed by a newline, will result in a printout of the text with the cursor in its new position.

EXAMPLE: You have typed in a program as follows:

```
(A "HELLO  THERE " N=? " IS N
WHAT NUMBER DO YOU WANT" ; . . . . . . .  etc
```

And you want to move the cursor to the spelling error.

Use: RN   i.e. move to start, move down a line, move in 5 characters.

Using a space instead of a newline will not print out the text but will carry out the actions and return the edit prompt.

Once we have moved the prompt to where we want to make adjustments we have commands to delete and insert characters.

D Remove (delete) the character pointed at by the cursor.
The cursor now points to the next character along.

Innnn; Insert the string nnnn before the character pointer.
The terminator is a ;* Cursor points to same character.

EXAMPLE: Edit ABCDERTYIJKLMNOP to replace RTY by FGH

ABCDEFRTYJKLMNOP

E:R Move pointer to start the along 7 characters (to Y)

ABCDEF–TYIJKLMNOP Character R appears at top R.H. side of screen.

E:D Delete current character.
ABCDEF–YIJKLMNOP T appears at top right.

E:DD Delete two more.

ABCDEF–JKLMNOP 1 appears at top right.

E:IGHI; Insert correct characters.

ABCDEFGHI–KLMNOP string now correct– O still current character.

When editing is complete, the command W is used to return to command mode.

4.0 ERROR MESSAGES

When a large program is written concisely in M5, errors may be difficult to detect so good errr diagnostics at runtime were included.

If a syntax error occurs, one of the following messages will appear:

SYM	FRR	x	The symbol x is not allowed in M5 (except in a string).
10	ERR	x	The symbol x is not a valid identifier, and an attempt was made to copy a value into it. (e.g. =x occurred.)
JID	ERR	x	The label x was not found when a jump occurred to it.
JC	ERR	x	The symbol x occurred in a jump condition position and is not a valid code (one of U A N Z X G E M).
	ERR	x	The symbol x caused an error to occur. (Not one of above.)

In addition to giving the error type, the editing cursor is set up to point at the faulty symbol, so when the editor is entered from the monitor to correct the error, the cursor is in the correct position for amendments.

(N.B. in M6, JID errors are detected before the program starts to execute.)

5.0 SAMPLE PROGRAMS IN M5

```
Number summing program    (A"INPUT A NUMBER"?," THANKS
----------------------       NOW INPUT 2 MORE NUMDERS"?,"AND"?"GOOD!
                             THEIR SUM IS "++=? "
                             ")NA "THEIR SUM WAS ZERO - TYPE 0 FOR MORE FUN OR
                             1 TO END "?)ZA "GOODBYE!" )M
Factorial of a number:   1=N ? )7B (A  =M , N* =N M# )NA (B N=?
-----------------------
M5 24 hour clock:
------------------         )US (D  N#=N )ND
(N.b. remove all           H=?" HRS "M=?" MINS "S=?" SECS
 spaces for good           " L=N S&=S , T )XD
 timekeeping )               0=S M&=M , T )XD
                             0=M H&=H ,24 )XD
                             0=H )UD
(Start put at end)         (S 1750=L  60=T
                           "SET HRS"?=H"SET MINS"?=M"SECS"?=S"
                           " )UD
```

Note that the main timing loop is at the beginning for higher speed.
1750 is the timekeeping constant. make smaller to speed up clock.

```
Square root of a number:  256=M  ?=N  (1  N,M/ , M )LS +,2/=M )U1
------------------------
                            (S " "M=?" "
Method used is very fast but a little hard to follow.

Prime numbers:          1=T
--------------        (N T&&=T
                        1=G
                      (A G&&=G
                        T,G/,G )GP
                        @ )NA )UN
                      (P T=? "
                        " )UN

This can be compacted to only one line of course, ( a bit baffling though ):
1=T(NT&&=T1=G(AG&&=GT,G/,G)GP@)NA)UN(PT=?" ")UN
```

```
Hexadecimal object code listing  23 MAR 79 14.14

Addr              Bytes                                Bytes
0C50   D6  3F  CD  01  0E  5E  23  56     18  3B  E1  ED  52  EB  18  35
0C60   C3  3E  0E  EF  3F  00  21  00     00  CD  25  0E  CD  14  0E  33

CC70   F8  EB  18  21  62  6B  FD  21     0A  0E  AF  FD  46  01  FD  4E
0C80   00  ED  42  38  03  3C  18  F9     09  C6  30  CD  3B  01  FD  23

CC90   FD  23  0D  20  E5  DD  23  DD     7E  00  FE  20  28  F7  FE  1F
0CA0   28  F3  FE  3F  28  BD  30  A8     FE  2C  28  30  FE  3D  28  33

0CB0   FE  29  CA  74  0D  FE  23  28     46  FE  26  28  3F  FE  2B  28
0CC0   36  FE  2D  28  95  FE  2A  28     39  FE  2F  28  56  FE  28  23

0CD0   0E  FE  22  28  6C  B7  CA  3E     0E  C3  54  0D  D5  18  86  DD
0CE0   23  18  B2  DD  23  DD  7E  00     D6  3F  28  88  DA  C7  0D  CD

0CF0   01  0E  73  23  72  18  9E  E1     19  EB  18  99  13  18  96  1B
CD00   18  93  C1  3E  10  21  C0  00     CB  7A  28  04  09  30  01  13

CD10   3D  28  09  EB  29  EB  29  30     EF  13  18  EC  EB  22  C0  08
CD20   C3  95  0C  42  4B  21  C0  00     D1  3E  10  29  EB  29  EB  30

CD30   02  23  B7  ED  42  13  F2  3C     0D  09  CB  83  3D  20  EC  18
0D40   DC  DD  23  DD  7E  00  FE  22     CA  95  0C  B7  CA  3E  0E  CD

CD50   33  01  18  ED  D6  30  FE  0A     30  13  21  00  00  DD  7E  00
0D60   DD  23  CD  14  0E  38  F6  EB     DD  2B  C3  97  0C  EF  53  59

0D70   4D  00  18  57  DD  7E  01  FE     4E  28  31  FE  55  28  5B  FE
CD80   5A  28  23  08  E1  E5  B7  ED     52  08  FE  45  28  24  FE  58

CD90   28  23  FE  4C  28  22  FE  47     28  23  FE  4D  CA  3E  0E  EF
CDA0   4A  00  DD  23  18  25  7A  B3     28  30  18  14  7A  B3  20  2A

0DB0   18  0E  08  18  F3  08  18  F6     08  30  1F  18  03  08  38  1A
CDC0   DD  23  DD  23  C3  95  0C  EF     49  44  00  EF  20  45  52  52

0DD0   20  00  DD  7E  00  CD  3B  01     18  64  DD  4E  02  31  FA  0F
0DE0   21  FE  0E  06  28  7E  23  B8     28  0D  B7  C2  E5  0D  DD  23

0DF0   DD  23  EF  4A  00  18  D0  7E     B9  20  EA  E5  DD  E1  C3  95
CE00   0C  07  4F  06  00  21  BE  0B     09  C9  10  27  E8  03  64  00

0E10   0A  00  01  00  D6  30  FE  0A     D0  29  54  5D  29  29  19  5F
0E20   16  00  19  37  C9  CD  3E  00     C3  3B  01  EF  1F  00  21  FD

CE30   0E  23  7E  B7  C8  CD  3B  01     18  F7  AF  77  23  77  EF  1F
0E40   4D  35  3A  00  CD  25  0E  FE     4C  CC  2B  0E  FE  49  CA  D3

CE50   0E  FE  52  20  09  EF  1F  00     DD  21  FD  0E  18  A0  FE  45
CE60   20  DC  DD  E5  E1  4E  36  7F     E5  79  32  F6  0B  CD  2B  0E

0E70   E1  71  EF  1F  45  3A  00  CD     25  0E  FE  44  28  3A  FE  1F
0E80   28  E3  FE  3E  20  01  23  FE     3C  20  01  2B  FE  52  28  22
CE90   FE  4E  28  34  FE  57  28  A6     FE  49  20  DB  CD  25  0E  FE
CEA0   33  28  D4  E5  4E  77  23  79     B7  20  F9  77  23  77  E1  23


0EB0   18  EA  21  FF  0E  2B  18  BF     E5  DD  E1  DD  7E  01  DD  77
0ECC   00  B7  28  B3  DD  23  18  F3     7E  B7  28  AB  23  FE  1F  20

0ED0   F7  18  A4  EF  6E  70  75  74     1F  00  21  FD  0E  23  CD  25
0EE0   0E  FE  3B  CA  3A  0E  77  FE     1D  20  F2  2B  18  F0  D4

       Execute from 0C60.   Program starts at 0EFF.
```