

# My Little Compiler & PreCompiler

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[http://gtello.pagesperso-orange.fr/mlc\\_e.htm](http://gtello.pagesperso-orange.fr/mlc_e.htm)

## 1° Purpose

### 1-a With a single TI 99 : MLC

Create fast assembly routines directly from Extended Basic:

- no assembly knowledge required
- no Editor/Assembler cartridge required

Just compose your routines with an easy macro language and send them to the compiler through DATA lines, and that's it!

Hardware required:

- A TI-99 with 32k Ram expansion, **F18A supported**.
- A disk system or equivalent (CF7 for example)

### 1-b Preparing your work on a PC: PreCompiler

If you have a PC and an easy way to transfer files to the TI 99, or eventually an emulator, then the PreCompiler is for you. It offers a high level language with some specific pseudo instructions that you don't find in MLC.

It translates this readable language into the MLC macro codes. Some features:

- High level language with comments to make your source code clear
- More loop structures than in MLC (FOR/NEXT, DO/WHILE/UNTIL...)
- Integration of the BASIC lines to manage the compilation
- Easy definition of characters as patterns
- An inline assembler to bypass the limits of MLC (no E/A cart required!)
- Support of the enhanced graphic processor F18A

## 2° How does it work?

### 2-a With a single TI 99 : MLC

First you must load the compiler, there are two ways, either the relocatable binary or the FastLoader.

```
CALL INIT::CALL LOAD("DSK1.MLCO")  
(Only one file required, but loading is very slow!)
```

*Or*

```
CALL INIT::CALL LOAD("DSK1.NEWFLO")::CALL LINK("NEWFLO")  
(Files required: NEWFLO the FastLoader and MLC1/MLC2 the compiler, 12 times faster but uses temporarily a large VDP Ram bloc).
```

Then you have access to those routines via a CALL LINK statement:  
FSIZE, POP, COMPIL

---

## FSIZE

---

Syntax: CALL LINK ("FSIZE", A, B)

Returns in A the amount of free bytes in Low Ram expansion and in B the amount of bytes used in High memory (starting at >A000).

In the earlier versions of MLC, you had the choice to compile either in low or high memory. But as MLC was growing, it took nearly all the Low ram space. So now the compilation is directed to High Memory and the instruction HIGHMEM nn (@nn) was removed.

You must be careful because High Memory is used by the TI Extended Basic to store the current program, but this space is used from >FFFF and downwards. See \$DEL section for details on Memory Map.

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## POP

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Syntax: CALL LINK ("POP", A, B)

Removes from memory the last routine compiled by COMPIL and returns in the variable Var the amount of free bytes in Low Ram expansion and in B the amount of bytes used in High memory (starting at >A000).

---

## COMPIL

---

Syntax: CALL LINK ("COMPIL", IO(), S\$(), C\$())

Compiles every information stored into DATA statements and turn them either into programs, sounds or characters according to the sections found.

Input:

IO(1) is the line number of the first DATA statement.

Output:

IO(1) is the error code or zero if Ok (see **Error Codes** section)

IO(2) is the line number of the error (if any)

IO(3) is the position of the error in the line (if any)

S\$() will contain the compiled sounds (if any)

C\$() will contain the binary character definitions (if any)

In the DATA section, you must follow some rules:

- Only one string per DATA line
- Each section starts with a single character code, ex: 3000 DATA P
- Each section ends with a null string, ex 3100 DATA ""
- The last section starts with a null string.

## **CODE P : Program section**

A program section looks like this:

```
DATA P
DATA PRGNAM                (max 6 characters for the name)
DATA ...MLC codes...      (max 128 bytes per line)
DATA ...MLC codes...
DATA ""
```

The program name PRGNAM must be from 1 to 6 characters long, it is the one you will use in the CALL LINK("PRGNAM",...) statement to call your assembly routine.

You can have several program sections to create more than one program.

### **Example:**

```
10 CALL INIT::CALL LOAD("DSK1.MLCO")
30 IO(1)=500::CALL LINK("COMPIL",IO(),S$( ),C$( ))
100 A=15::B=20
110 CALL LINK("TEST",A,B)
120 PRINT A,B :: END
500 DATA P
510 DATA TEST
520 DATA G1X G2Y P1Y P2X
530 DATA ""
540 DATA ""
```

The program name will be TEST, in 520 I wrote a simple useless program that:

- takes parameter 1 into variable X (G1X)
- takes parameter 2 into variable Y (G2Y)
- put variable Y into parameter 1 (P1Y)
- put variable X into parameter 2 (P2X)

So, this routine exchanges value of the two parameters passed to CALL LINK. After the call A=20 and B=15.

## **CODE S : Sound section**

A sound section allows you to create a sound to use it in your program. It looks like this:

```
DATA S
DATA n                (string index where to store the sound)
DATA ...sound codes...
DATA ...sound codes...
DATA ""
```

When the sound is compiled, the binary codes are stored into S\$(n). You can have as many sound sections as you want, take care to provide enough space in the S\$( ) array.

Then the S\$( ) array can be passed to your assembly routine that will play them using the "&M" function (*see MUSIC AND SOUND section for more details*).

## **CODE C : Character section**

The character section allows you to define the patterns that will be used in your program. The section looks like this:

```
DATA C
DATA ...char def...
DATA ...char def...
DATA ""
```

Every char definition must have exactly:

- 16 hexadecimal signs for a single character
- 32 hexadecimal signs for two consecutive characters
- 48 hexadecimal signs for three consecutive characters
- 64 hexadecimal signs for four consecutive characters

Every DATA line is then turned into binary codes and stored into the C\$() string array in sequence (*unless you specify a fixed character number*). This means that the first definition will be stored into C\$(1), the next into C\$(2) and so on.

Once in binary mode, you can pass them as parameters to your compiled program and use those definitions with the &D or &d instructions (*see &D for more details*).

*Note: only one char section is allowed, else each would overwrite the previous definitions starting again at C\$(1)!*

A char definition, if used only once, can be sent directly to VDP Ram to define a char at compilation time. So you save memory because no string is stored into C\$() and time because the &D or &d instruction is not used. To do so, you must precede the definition with the char number and a point:

Snnn to send it to the standard zone  
Xnnn to send it to the extended zone (*see **Pattern discussion***)

Example:

```
DATA C
DATA 00FF00FF00FF00FF           ; sent to C$(1)
DATA S65.FF8181818181FF         ; def char 65 in standard zone
DATA X255.007E7E7E7E7E00        ; def char 255 in extended zone
DATA 0103070F1F3F7FFF           ; sent to C$(2)
DATA ""
```

## **CODE D : Delete previous DATA**

Insert a DATA D between two sections to free memory at compilation time. *See \$DEL in the next **PreCompiler** paragraph for details.*

## 2-b On a PC: PreCompiler

Just run PreCompiler.exe and you're driven to a menu where you have to:

- Select once the text editor you want to use (this will be saved)
- Select the source file, I recommend using a name with TXT extension.

Then you can edit this source file, compile it and view the compiled source code. This last has the same name but with BAS extension.

### Source organization:

You just write BASIC lines as if they were typed on a real TI and you have some directives to include the lines containing:

- The loader and the compilation
- The MLC routines to be compiled
- The sounds
- The char definitions

Basically, a source looks like this:

```
100 CALL CLEAR::DIM S$(..),C$(..)
    ... the MLC directive to include the compiler
$MLC F 110 10 3000
300 ... my basic code...
310 some CALL LINK("MYPROG",params...)
$MYPROG
    ...here the source code for MLC...
$$
    .. and eventually :
$SND 1
    ... def for sound one...
$$
$SND n
    ... def for sound n...
$$
    .. and eventually:
$GPU
    ... here the GPU assembly program (before $CHAR!)...
$$
$CHAR
    ... here char definitions
    ... eventually using $PATTERN/$$
$$
$END
```

You can see that \$MLC directive includes the compiler management. Every other directive is a bloc \$DIRECTIVE ...\$\$ and that the last \$\$ must be followed by \$END to finalize the source code.

---

## \$MLC

---

**Syntax:** \$MLC mode start inc data  
Includes the BASIC lines to load MLC and run compilation.  
Mode: can be

- N** **for standard slow loading**  
*This is just a CALL LOAD("DSK1.NEWMLCO")*
- F** **to use the FastLoader**  
*It uses the Fast loader CALL LOAD("DSK1.NEWFL0")*  
*It reads DSK1.NEWMLC to recreate NEWMLCO in memory*  
*Advantage FAST!*
- D** **don't load the compiler**, just run compilation assuming MLC's loaded.

*If mode is followed by a S (NS, FS or DS) then it is "silent" mode, you don't get any screen information regarding the loading or compilation. This can be useful if you have something like a title on screen!*

Start is the start line where to put the loader  
Inc is the increment between lines  
Data is the start line of the data section that will be created with your MLC program, sounds and char definitions.

**Example:** \$MLC F 110 10 3000

The loader/compiler will use the FastLoader starting at line 110 with increment 10 (110, 120, etc..) and the data section will start at line 3000 using the same increment.

---

## \$SND

---

**Syntax:** \$SND i  
... sound definition...  
\$\$

This includes a definition for sound i that will be stored into S\$(i) string. So you must provide a DIM S\$(..) fitting your needs.

Then the S\$(0) array can be passed to your assembly routine that will play them using the "SOUND" function (*see MUSIC AND SOUND section for more details*).

---

## \$PRGNAM

---

**Syntax:** \$PRGNAM (0)  
.. program instructions...  
\$\$

*If followed by 0, then there is no space between instructions in the DATA lines.*

Defines a bloc with a program to be compiled with MLC.

PRGNAM is the program name and can't exceed 6 characters. This is the exact name you will use in your CALL LINK("PRGNAM"... ) statements!

Of course, PRGNAM can't be MLC, SND, CHAR or END as they are reserved for the other directives.

Several program blocs can be defined.

**Example:**

```
$PLUS1
    GETPARAM 1 A
    INC A
    PUTPARAM 1 A
$$
```

With `CALL LINK("PLUS1",N)` you'll get in return a value incremented by one.

---

## \$CHAR and \$PATTERN

---

**Syntax:**

```
$CHAR
... char defs that can be definitions with
    $PATTERN
    ...
    $$
$$
```

This section allows you to prepare char definitions for your MLC program.

Each definition is similar to the `CALL CHAR` hexadecimal standard and can be for one, two, three or four consecutive characters. This is known by the PreCompiler with the length of the string you write:

- one char if exactly 16 signs
- two chars if exactly 32 signs
- three chars if exactly 48 signs
- four chars if exactly 64 signs

**Example:**

```
$CHAR
    FF818181818181FF           ; defines a square
    00E070381F3870E000180C06FF060C18 ; defines an arrow
$$
```

The first def will be stored into `C$(1)` and the second into `C$(2)`. You'll be able to use this definitions in you MLC program with the `DEFCHAR` or `XDEFCHAR` instructions (*see **Screen Instructions** for details*).

A char definition, if used only once, can be sent directly to VDP Ram to define a char at compilation time. So you save memory because no string is stored into `C$()` and time because the `DEFCHAR` or `XDEFCHAR` instruction is not used. To do so, you must precede the definition with the char number and a point:

- Snnn to send it to the standard zone
- Xnnn to send it to the extended zone (*see **Pattern discussion***)

**Example:**

```
$CHAR
  S65.FF818181818181FF          ; defines a square for standard char 65
  X9.00E070381F3870E000180C06FF060C18
                                   ; defines an arrow for extended chars 9 and 10
$$
```

If you're not familiar with the hexadecimal definitions, you can use \$PATTERN to define graphically a character, the previous section could have been written like this:

```
$CHAR
  $PATTERN          ; a square
                    ;(or use $PATTERN S65 to define standard char 65)
                    00000000
                    0.....0
                    0.....0
                    0.....0
                    0.....0
                    0.....0
                    0.....0
                    0.....0
                    00000000
  $$

  $PATTERN          ; an arrow
                    ;(or use $PATTERN X9 to define extended chars 9 and 10)
                    .....
                    000.....00..
                    .000.....00..
                    ..000.....00.
                    ...0000000000000
                    ..000.....00.
                    .000.....00..
                    000.....00...
  $$
$$
```

For a pattern, use a period “.” for a white pixel and any other character for a black pixel. I use “0”, but a “\*” can be ok too.

Note: only one \$CHAR bloc is allowed!

---

\$END

---

Syntax:        \$END

This directive must follow the last \$\$ of the last bloc to finalize the source code.



Syntax:     \$GPU  
          ... GPU assembly program ...  
          \$\$

For those owning a F18A graphic processor, you can define an assembly program that will be executed by the GPU (the processor located into the F18A) in parallel with your CPU.

**Only assembler can be used in this section!**

The F18A extends the VDP Ram with 2 extra KB from >4000 to >47FF, that's where MLC will copy this program. The GPU is a clone of the TMS9900 with those differences:

- It can only access VDP RAM from >0000 to >47FF
- The registers R0-R15 are fixed and not memory mapped
- You can't access the ROM routines from it

With the PreCompiler, this section is turned into a "CHAR" section whose definitions correspond to the binary codes of the program (*it was a trick to reuse some existing routines*). Those defs are sent to the VDP with the Xnnn directive at compilation time in the extended character bloc starting at >1000.

Then, the GPU itself is called to move this program to >4000, the final location.

**Note:** Knowing this, **the \$GPU section must precede every \$CHAR section** where the Xnnn directive is used, else characters will be overwritten by the GPU routine.

See "*F18A support*" section for more informations.

---

\$DEL

---

Syntax:       \$DEL

This directive can only appear between two sections (*i.e. after a \$\$*) and allows you to remove from memory all the previous DATA lines that have already been parsed by the compiler to free memory. You must understand how MLC manages the memory:

### **High Memory Map with MLC**

|       |     |   |
|-------|-----|---|
| >A000 | 32  | <b>My Workspace</b> , Registers R0-R15  |
| >A020 | 52  | <b>Variables A-Z</b>  |
| >A054 | 6   | <b>Pseudo variables</b> [ , \, ] for debugging  |
| >A05A | 256 | <u>Compiling program</u> :           labels addresses and references<br><u>Compiling Sounds and chars</u> : temporary string space<br><u>At run time</u> :                   free, can be reserved with DIMTABLE 0<br>or FARRAY 0 |
| >A15A | ??  | Data and tables for MLC   |
| >Axxx |     | Here starts your own programs   |

... Free Space ...

|         |  |
|---------|--|
| (>8386) | <b>last free address in memory</b> , here the numeric variables  |
| (>8330) | <b>table for BASIC lines</b> (each entry: WORD line number, WORD line address)<br><i>Lines appear in reverse order (the last line first)</i> |
| (>8332) | <b>last byte of the line table</b>   |
|         | <b>Tokenized BASIC lines</b><br><i>Lines appear in reverse order that they were entered<br/>(not the number line order!)</i>                 |
| >FFFF   | <b>End of High Memory</b>  |

The **Extended Basic** uses the High Memory from the end (>FFFF) and backwards. That's why the **MLC** uses this memory from the start (>A000) and forwards. The two systems can conflict if one overwrites the other.

## How to estimate the free space?

The **command SIZE** gives you the amount of free memory for program in Extended Basic, this is the size from >A000 to the GPL Substack, lets say: *21500 bytes*.

Then **CALL LINK("FSIZE",A,B)** returns in B the amount of memory used by MLC in High Memory, this is the size from >A000 to the end of your compiled programs, let's say *9200 bytes*.

Then the available memory is:  $21500 - 9200 = 12300$  bytes.

## Standard use of \$DEL

- If you think **you are short in memory**, then using \$DEL can save you! The idea is that:
  - 1) First define the characters, they are sent to VDP Ram (*in the pattern zone or in C\$ ( )*)
  - 2) Define your sounds, they are sent to VDP Ram (*in S\$ ( )*)
  - 3) Use \$DEL to remove DATA lines concerning chars and sounds
  - 4) With the extra space you just gained, your compiled program has more space!
  
- To be **even more efficient** if you still need space, you can separate your program in two blocs:
  - 1) First bloc, define all your tables and everything that will be done once (for example the color definitions, etc), let's say you name this \$TABLE
  - 2) Use \$DEL to remove DATA lines concerning this first part
  - 3) Then define your actual program with more space, let's say you name it \$MYPRG

At run time, `CALL LINK ("TABLE") :: CALL LINK ("MYPRG") .`

- **Important note:** after compiling remember that your program has changed, DATA lines have been removed! So save it BEFORE running it, and not after...!
  
- **Not less important note:** \$DEL can only work if lines were entered in order. Else, memory will be in a total mess. If you work directly on the TI-99 and modify one line, then this one will become the first line in memory. To get back the normal order, use SAVE AS and MERGE. If you use an emulator, like Classic99, prepare your source in an editor and "PASTE" it.
  
- **More than important note:** After compilation, if you use \$DEL, *all numeric variables are lost!* Their address has changed. So, you must make the compilation very soon in your program, then fill in the numeric variables. Don't expect to find them equal to zero, you MUST initialize them after compilation.

### Using free space at run time

While your program is running, you can use this little assembly routine to get the address and size of the free space using the assembly reference HIGHPT that is the internal pointer of MLC to its first free address in **High Memory**:

```
$[
    mov @>8386, r0 ; last free byte for Extended Basic
    mov @highpt, r1 ; first free byte for MLC
    s r1, r0 ; r0 = r0 - r1
    inc r0 ; one byte was missing, free size
    mov r1, @A ; address in A
    mov r0, @B ; size in B
$]
```

This returns in A the starting address of the free space and in B the size in bytes you can use without overwriting the Basic space.

The same for the **Low Expansion ram**. Even if MLC is stored there, there may be some bytes free (not guaranteed, this changes at every version):

```
$[
    mov @LFADDR, r0 ; start of REF/DEF table
    mov @FFADDR, r1 ; end of the compiler zone
    s r1, r0 ; free space between the two
    mov r1, @A ; address in A
    mov r0, @B ; size in B
$]
```

## 3° My Little Language

In the following section, each instruction will be described both for MLC and for the PreCompiler. For example:

---

|          |                 |  |          |
|----------|-----------------|--|----------|
| <b>G</b> | <b>GETPARAM</b> | get a parameter from the Call Link statement | <b>Z</b> |
|----------|-----------------|--|----------|

---

Tells you that “G” is the MLC macro-code, that “GETPARAM” is the equivalent in the PreCompiler. Then you have a short description.

If a “Z” is present, then, the result of this instruction is compared to zero, so you can use jump instructions according to this.

### 3-a With a single TI 99 : MLC

This language is a serie of codes (one letter or two) followed by zero to three arguments.

Arguments can be:

- one of the 26 predefined variables named A to Z, they can contain an integer from -32768 to +32767
- a numeric constant from -32768 to 32767. If an instruction has two constant arguments, the “.” can be used as a separator if needed.
- a single character that represents its ASCII value, use \$ followed by the desired character. For example \$3 represents the ASCII value 51. Single characters are treated the same as constants.

Instructions can be separated by one or more spaces (for readability) but can be stuck together (for compacity). But, a code can’t be separated from its arguments.

Conventions:

- k a numeric constant
- v a variable
- n number, either variable or constant
- c a character

#### Persistence of a variable:

Calling “COMPIL” erases all variables from A to Z.

Else, if you only call your own routines, their values are kept from one call to another.

All of your routines share the same variable space.

### 3-b On a PC: PreCompiler

The language is a series of instructions followed by zero to three arguments, most of them are synonyms of MLC macro codes, but others, referenced as pseudo-instructions, are constructions using several MLC codes.

**Only one instruction is allowed per line.**

One line can be followed by a comment starting with “;”. Any comment is cut at compilation time, they are only here for your convenience.

Arguments can be:

- one of the 26 **predefined variables** named A to Z, they can contain an integer from -32768 to +32767
- a numeric decimal constant from -32768 to 32767.
- a numeric **hexadecimal** constant with **&h prefix** (from &h000 to &hFFF)
- a numeric **binary** constant with **&b prefix** (from &b0 to &b1111111111111111)
- a single **character** with **\$ prefix** (ex: \$A is equivalent to 65)
- a **speech word** address with **&w prefix** (ex &wHELLO)

Arguments must be separated by either a space, a comma or parenthesis.

**Example:**

```
PUTCHAR 10 7 65 ; write a “A” at position 10,7
```

For readability you can write:

```
PUTCHAR (10, 7), $A
```

To show that 10 and 7 are a set of coordinates. You choose the appearance you prefer!

```
AND E 255 ; remove upper byte
```

For readability on binary operations you can write:

```
AND E &h00FF
```

## Variable initialization

---

|   |            |  |          |
|---|------------|--|----------|
| = | <b>LET</b> | store a value into a variable or memory location | <b>Z</b> |
|---|------------|--|----------|

---

Syntax:        =nn'

Make n=n'. If n is a constant, then it is considered as a memory address.

Ex:    =A-10        A=-10  
      =DF         D=F  
      =8192A      poke word A into 8192  
      =8192.65535 poke >FFFF into 8192

➤ **With the PreCompiler, syntax:    *LET n n'***

Ex:    LET A -10  
      LET D F  
      LET 8192 A  
      LET 9182 &hFFFF

---

|   |             |  |  |
|---|-------------|--|--|
| X | <b>SWAP</b> | exchange two variables or memory locations |  |
|---|-------------|--|--|

---

Syntax:        Xnn'

Exchange values of n and n'. If one parameter is a constant, it is considered as a memory address. This is the only way to “peek” values from memory.

Ex:    XPS         P=S and S=old value of P  
      XA8192      exchange words in variable A and location 8192.  
      X8192.8194 exchange two memory words at 8192 and 8194.

➤ **With the PreCompiler, syntax:    *SWAP n n'***

Ex:    SWAP P S  
      SWAP A 8192  
      SWAP 8192 8194

---

|   |                 |  |          |
|---|-----------------|--|----------|
| G | <b>GETPARAM</b> | get a parameter from the Call Link statement | <b>Z</b> |
|---|-----------------|--|----------|

---

Syntax:        Gnn'

Get parameter number n and store it into n' variable or memory location.

**Note:** if the parameter is an array, you must use TG (see **Arrays** section).

Ex:    assuming CALL LINK(“TEST”,D,E,F)  
      G1A         A = integer value taken from D in basic (1<sup>st</sup> parameter)  
      GZA         Take from Z the parameter number (must be 1, 2 or 3 for D, E  
and F) and according to its value, stores in A the corresponding parameter.  
      G1.12000    poke integer value of parameter 1 into memory location 12000.

➤ **With the PreCompiler, syntax:    *GETPARAM n n'***

Ex:    GETPARAM 1 A  
      GETPARAM Z A  
      GETPARAM 1 12000

---

P     **PUTPARAM** put a value into a parameter in the Call Link statement

---

Syntax:     Pnn'

Stores a value into one of the variables in the Call Link statement. If n' is a numeric constant, it is not considered as a memory location but as a value. So you can't send directly a memory word to a Basic parameter. you have to use X (exchange) before.

**Note:** *if the parameter is an array, you must use TP (see **Arrays** section).*

Ex:     assuming CALL LINK("TEST",D,E,F)  
      P3Z             give to F (3<sup>rd</sup> parameter) the integer value of Z  
      P1.5            give to E (1<sup>st</sup> parameter) the value 5.  
      PZ-8            take from Z the parameter number (must be 1, 2 or 3) and  
according to its value, stores -8 in the corresponding parameter.

➤ **With the PreCompiler, syntax:**     **PUTPARAM n n'**

Ex:     PUTPARAM 3 Z  
      PUTPARAM 1 5  
      PUTPARAM Z -8





➤ **With the PreCompiler**, syntax: **GETTABLE t(i) v**

Ex: GETTABLE A(2) E  
GETTABLE Q(5) F  
GETTABLE N(A) B

(\*) **String arrays in CALL LINK**: the value returned is not the string itself, but the VDP Ram address of the string and Z contains the length of the string.  
Comparison to zero is performed on the value of Z.

Note: if the string is a simple variable, then use  $i=0$ .

Example: CALL LINK("TEST",A\$,B\$())

=U2 to access second array B\$()

TGU3M makes M=VDP RAM address of B\$(3) and Z=len(B\$(3))

Using M is interesting as it can be the name of a byte array in VDP RAM, what a string is!

=X1 to access first variable A\$

TGX0N makes N=VDP RAM address of A\$ and Z=len(A\$).

?=a and jumps to label a if len is zero.

➤ **With the PreCompiler**,

Ex: LET U 2  
GETTABLE U(3) M

LET X 1  
GETTABLE X(0) N  
IF=THEN a

---

|    |                 |                                   |
|----|-----------------|-----------------------------------|
| TP | <b>PUTTABLE</b> | put a value into an array element |
|----|-----------------|-----------------------------------|

---

Syntax: TPtin

Make  $t(i) = n$  **except for string (arrays) in CALL LINK(\*)**

t must be an array name, i and n variables or numeric constants.

Ex: TPS3.-1 make  $S(3) = -1$ , S refer to an array in the CALL LINK statement. Assuming CALL LINK("TEST",A(),B(),C()) and S=1, then S(3) refer to A(3) as A() is the 1<sup>st</sup> array in the list.

TPFAB make  $F(A) = B$  a byte value in CPU RAM. If  $F = 8192$ ,  $A = 100$  and  $B = 214$ , put byte 214 into CPU location  $8192+100 = 8292$ .

➤ **With the PreCompiler**, syntax: **PUTTABLE t(i) n**

Ex: PUTTABLE S(3) -1  
PUTTABLE F(A) B

(\*) **String (arrays) in CALL LINK**: the value n must be a variable containing the CPU address of the string (typically a BYTE table name such as E, F, G or H) and variable Z must contain the length of the string.

If you use  $i=0$  then the parameter in CALL LINK can be a simple string variable.

Ex: With CALL LINK("TEST",A\$( ),S\$)  
 TRF50                    F a table with 50 bytes maxi  
 ...  
 =Z10  
 TP1.4F                    send a 10 bytes string from table F to A\$(4)  
 TP2.0.F                    send a 10 bytes string from table F to S\$.

➤ **With the PreCompiler**

Ex: DIMTABLE F 50  
 ...  
 LET Z 10  
 PUTTABLE 1 (4) F  
 PUTTABLE 2 (0) F

---

TF    **FILLTABLE**            fills a table with a value

---

Syntax:            TFtnv  
 t must be a table either in CPU or VDP RAM (from A to P). "n" is the number of elements to fill with value "v".

Ex:    TFA10.5000    10 first words of A are filled with value 5000 in CPU ram.  
       TFM12.0        12 first bytes of M are filled with 0 in VDP ram.

➤ **With the PreCompiler, syntax:    *FILLTABLE t n v***

Ex: FILLTABLE A 10 5000  
 FILLTABLE M 12 0

---

TR    **DIMTABLE**            reserve a table in CPU RAM

---

Syntax:            TRts  
 t must be a table name in CPU RAM (from A to H), at compilation time this instruction reserves s words (name from A to D) or s bytes (name from E to H). At run time it gives to the "t" variable the address of the first element of the array.  
 "s" (size) must be a constant as it has to be know at compilation time!

Ex:    TRD32            reserve 32 words (64 bytes) and give D the first address.  
       TRE32            reserve 32 bytes and give D the first address.

➤ **With the PreCompiler, syntax:    *DIMTABLE t s***

Ex: DIMTABLE D 32  
 DIMTABLE E 32

Special value: if you use a size of ZERO, the variable is given the value of a 256 bytes zone used by the compiler for label references.

Ex:    TRA0            A points to a space with 128 words.  
       TRE0            E points to a space with 256 bytes.

➤ **With the PreCompiler**

Ex: DIMTABLE A 0  
DIMTABLE E 0

You must know that if you use again “COMPIL” the values in this array will be lost.

---

TM **BMOVE** move bloc of bytes in CPU RAM

---

Syntax: TMsnd

Copy from source address s to dest address d a bloc of n bytes in CPU RAM.

Ex: TRE50 reserve 50 bytes and address in E  
TRF50 idem for F  
TME50F copy table E to table F

➤ **With the PreCompiler, syntax: *BMOVE s n d***

Ex: DIMTABLE E 50  
DIMTABLE F 50  
BMOVE E 50 F

---

TW **WMOVE** move bloc of words in CPU RAM

---

Syntax: TWsnd

Copy from source address s to dest address d a bloc of n words in CPU RAM.

Ex: TRA20 reserve 20 words and address in A  
TRB20 idem for B  
TWB20A copy table B to table A

➤ **With the PreCompiler, syntax: *WMOVE s n d***

Ex: DIMTABLE A 20  
DIMTABLE B 20  
WMOVE B 20 A

---

TC **BMOVECTOV** move bloc of bytes from CPU RAM to VDP RAM

---

Syntax: TCsnd

Copy from source address s in CPU RAM to dest address d in VDP RAM a bloc of n bytes.

Ex: TRE32 reserve 32 bytes and address in E  
TWE32.0 copy table E to table VDP address 0, so overwrites first screen line !

➤ **With the PreCompiler, syntax: *BMOVECTOV s n d***

Ex: DIMTABLE E 32  
BMOVECTOV E 32 0

---

TV    **BMOVEVTOC**    move bloc of bytes from VDP RAM to CPU RAM

---

Syntax:    TCsnd

Copy from source address s in VDP RAM to dest address d in CPU RAM a bloc of n bytes.

Ex:    TRE768    reserve 768 bytes and address in E  
      TW0.768E    copy 768 bytes from VDP address 0 into E, so, save the whole screen into table E.

➤ **With the PreCompiler**, syntax:    **BMOVEVTOC s n d**

Ex:    DIMTABLE E 768  
      BMOVEVTOC 0 768 E

---

TO    **BYTE**    write One byte at the current compilation address

---

Syntax:    TOn

N must be a constant (0-255 or -128-+127), this is used to initialize tables of bytes. *See below.*

➤ **With the PreCompiler**, syntax:    **BYTE n**  
If you have more than one byte to initialize, then use **BYTES n1,n2,...**

---

TT    **WORD**    write Two bytes at the current compilation address

---

Syntax:    TTn

N must be a constant (0-65536 or -32768-32767), this is used to initialize tables of words. *See below.*

➤ **With the PreCompiler**, syntax:    **WORD n**  
If you have more than one word to initialize, then use **WORDS n1,n2,...**

---

TH    **HEX**    write hexadecimal bytes at the current compilation address

---

Syntax:    THn.hhhh...

n must be a constant (0-255) and following must be a "." and n bytes using each two hexadecimal digits. Ex: TH6.AA12FF06C31E

➤ **With the PreCompiler**, syntax:    **HEX hhhh...**  
Note that you don't need to specify the length with the PreCompiler.

---

TS    **STRING**    write a string at the current compilation address

---

Syntax:        TSn.XXX...

n must be a constant (0-255) and following must be a "." and n characters. The string can't be cut into two different compilation strings. If it's too long, just use several TS statements.

This is used to initialize a string constant. *See below.*

➤ **With the PreCompiler**, syntax:    **STRING "XXX..."**

Note that you don't need to specify the string length with the PreCompiler, it does this for you, but you must enclose the string with "...".

---

TJ    **SKIP**        jump over a block and update the compilation address

---

Syntax:        TJn

The compilation pointer is incremented by n.

➤ **With the PreCompiler**, syntax:    **SKIP n**

Note: you may have to use *EVEN* if n is odd.

---

TE    **EVEN**        ensure that the current compilation address is even

---

Syntax:        TE

Turns to even the current pointer of compilation if it was odd after TS or TO statement. This is absolutely necessary because assembly instructions must start on an even address. *See below.*

➤ **With the PreCompiler**, syntax:    **EVEN**

---

T<    **STOREPTR**    store the current compilation address

---

Syntax:        T<

Store the current compilation address into a temporary space. This is mostly used before a table or string initialization to get the starting address. *See below.*

➤ **With the PreCompiler**, syntax:    **STOREPTR**

---

T>    **RECALLPTR**    recall the current compilation address

---

Syntax:        T>V

Give to variable V the value stored in the temporary space with "T<". So now V points to the address you've saved. *See below.*

➤ **With the PreCompiler**, syntax:    **RECALLPTR V**

## Note on Data initialization:

### a- With MLC

Typically, you have to do this:

```
B0          Jump over the table
T<          To save the starting address
...here use TO, TT, TH, TJ or TS to put your data...
TE          eventually if you used TO, TJ or TS
L0          the label you've jumped to
T>V        get the address back into your variable.
```

Then your variable will point at the starting address of data.

#### Some example here:

**Initialize a table of 5 WORDS** (the variable will be A to point to a WORD table):

```
B0 T< TT85 TT62 TT42 TT13 TT14 L0 T>A
    Then A(0)=85,... and A(4)=14.
```

**Initialise a table of 7 BYTES** (the variable will be E to point to a BYTE table) :

```
B0 T< T00 T01 T04 T09 T016 T025 T036 TE L0 T>E
    Then E(0)=0, ... E(6)=36 the square table!
    Note the use of TE because the number of bytes is odd.
```

**Initialize a string** (the variable will be E to point to a BYTE table):

```
B0 T< TS10ABCDEFGHIJ TS10KLMNOPQRST TS6UVWXYZ TE L0 T>E
    Then E(0)='A',...E(25)='Z'
    Note that the whole string can be passed at the time with
    TS26ABCDEFGHIJKLMNQRSTUWXYZ
```

That was just to show the string cut..

**Note:** if you don't use the BRANCH instruction before your table, then the assembler will interpret your data as instruction codes and will try to execute them.

This can lead to weird results.

### b- With the PreCompiler

Typically, you have to do this:

```
STARTDATA
...here use BYTE(S), WORD(S), HEX, SKIP or STRING...
ENDDATA V
```

Then your variable V will point to the start of your table.

### Some example here:

**Initialize a table of 5 WORDS** (the variable will be A to point to a WORD table):

```
STARTDATA
  WORDS 85, 62, 42, 13, 14
ENDDATA
  Then A(0)=85,... and A(4)=14.
```

**Initialise a table of 7 BYTES** (the variable will be E to point to a BYTE table) :

```
STARTDATA
  BYTES 1, 4, 9, 16, 25, 36
ENDDATA E
  Then E(0)=0, ... E(6)=36 the square table!
  Note that the number of bytes is odd, ENDDATA manages this internally to keep an
  even address for the next instructions.
```

**Initialize a string** (the variable will be E to point to a BYTE table):

```
STARTDATA
  STRING "ABCDEFGHJKLMNOPQRSTUVWXYZ"
ENDDATA E
  Then E(0)='A',...E(25)='Z'
```

---

### ***STARTDATA***

---

Syntax:       ***STARTDATA***

Marks the beginning of a data block. It is a pseudo-instruction, combination of MLC codes with B (Goto) and T< (StorePtr) and has no direct equivalent in MLC.

---

### ***ENDDATA***

---

Syntax:       ***ENDDATA v***

Marks the end of a data block and v is equal to the starting address of the block.

This is a pseudo-instruction, combination of MLC codes with L (Label), TE (Even) and T> (RecallPtr) and has no direct equivalent in MLC.

## **How to know the size of a data block?**

In MLC, the word just before a table is the address of the end of the table. With a simple operation you can compute the table length, example:

```
STARTDATA
  BYTES 1, 2, 3, 4, 5           ; 5 bytes
  STRING "YES"                 ; 3 bytes
  WORDS -1, 0, 1               ; 6 bytes in 3 words
ENDDATA A                      ; total of 14 bytes
GETTABLE A(-1) B               ; take the word before the table B=end address
SUB A B                        ; B=end-start, so B is the length of the table, 14.
```



That was easy because the block was pointed to by A, a word array pointer. What happens if the bloc is pointed to by E, a byte array pointer?

```
STARTDATA
```

```
... .
```

```
ENDDATA E
```

```
LET A E
```

```
GETTABLE A (-1) B
```

```
SUB A B
```

```
; first, put E into a word array pointer as A  
; take the word before the table B=end address  
; B=end-start, so B is the length of the table.
```

## Arithmetic Instructions

---

|          |                             |  |          |
|----------|-----------------------------|--|----------|
| <b>D</b> | <b><i>DEC</i></b> decrement |  | <b>Z</b> |
|----------|-----------------------------|--|----------|

---

Syntax:        Dn  
Decrement the variable or memory location by one.

Ex:     DC            C=C-1  
       D16000        memory location 16000-16001 is decremented by one

➤ **With the PreCompiler**, syntax:    ***DEC n***

Ex:    DEC C  
       DEC 16000

---

|          |                             |  |          |
|----------|-----------------------------|--|----------|
| <b>I</b> | <b><i>INC</i></b> increment |  | <b>Z</b> |
|----------|-----------------------------|--|----------|

---

Syntax:        In  
Increment the variable or memory location by one.

Ex:     IC            C=C+1  
       I16000 memory location 16000-16001 is incremented by one

➤ **With the PreCompiler**, syntax:    ***INC n***

Ex:    INC C  
       INC 16000

---

|          |                            |  |          |
|----------|----------------------------|--|----------|
| <b>A</b> | <b><i>ABS</i></b> absolute |  | <b>Z</b> |
|----------|----------------------------|--|----------|

---

Syntax:        An  
Replaces the argument by its absolute value.

Ex:     AF            F=abs(F)  
       A24000        memory location 24000-24001 replaced by its absolute value

➤ **With the PreCompiler**, syntax:    ***ABS n***

Ex:    ABS F  
       ABS 24000

---

|          |                          |  |          |
|----------|--------------------------|--|----------|
| <b>N</b> | <b><i>NEG</i></b> negate |  | <b>Z</b> |
|----------|--------------------------|--|----------|

---

Syntax:        Nn  
Replaces the argument by its opposite value.

Ex:     NF            F=-F  
       N24000        memory location 24000-24001 replaced by its opposite value

➤ **With the PreCompiler**, syntax:    ***NEG n***

Ex:    NEG F  
       NEG 24000

---

|          |                     |                  |  |
|----------|---------------------|------------------|--|
| <b>Z</b> | <b><i>CLEAR</i></b> | clear a variable |  |
|----------|---------------------|------------------|--|

---

Syntax:        **Zn**

Clear the variable giving it a null value.

Ex:    **ZA**                make A = 0  
      **Z8200**            make bytes at locations 8200-8201 equal to zero.

➤ **With the PreCompiler, syntax:    *CLEAR n***

Ex:    **CLEAR A**  
      **CLEAR 8200**

---

|          |                   |                     |                 |
|----------|-------------------|---------------------|-----------------|
| <b>+</b> | <b><i>ADD</i></b> | sum into a variable | <b><i>Z</i></b> |
|----------|-------------------|---------------------|-----------------|

---

Syntax:        **+vn**

Sums n to v. If V is a constant, then it's a memory location.

Ex:    **+AB**                **A=A+B**  
      **+A92**                **A=A+92**  
      **+15000C**            add C into memory location 15000-15001

➤ **With the PreCompiler, syntax:    *ADD v n***

Ex:    **ADD A B**  
      **ADD A 92**  
      **ADD 15000 C**

---

|          |                   |                        |                 |
|----------|-------------------|------------------------|-----------------|
| <b>-</b> | <b><i>SUB</i></b> | subtract to a variable | <b><i>Z</i></b> |
|----------|-------------------|------------------------|-----------------|

---

Syntax:        **-vn**

Subtract n to v. If V is a constant, then it's a memory location.

Ex:    **-AB**                **A=A-B**  
      **-A92**                **A=A-92**  
      **+15000C**            subtract C into memory location 15000-15001

➤ **With the PreCompiler, syntax:    *SUB v n***

Ex:    **SUB A B**  
      **SUB A 92**  
      **SUB 15000 C**

---

|   |                   |                   |                  |
|---|-------------------|-------------------|------------------|
| / | <b><i>DIV</i></b> | divide a variable | <b><i>Z*</i></b> |
|---|-------------------|-------------------|------------------|

---

Syntax:        /vn

Divide v by n and return the quotient in v and the remainder always in variable Z. Both values must be positive!

Ex:     assuming that A=255 and B=7

      /A10            divide A by 10, so A=25 and remainder Z=5 (255=25\*10+5)

      /AB             divide A by B, so A=36 and remainder Z=3 (255=36\*7+3)

➤ **With the PreCompiler**, syntax:     ***DIV v n***

Ex:     DIV A 10

      DIV A B

***Z\****: note that the comparison to ZERO is performed on the remainder, not the quotient!

---

|   |                   |                     |                 |
|---|-------------------|---------------------|-----------------|
| * | <b><i>MUL</i></b> | multiply a variable | <b><i>Z</i></b> |
|---|-------------------|---------------------|-----------------|

---

Syntax:        \*vn

Multiply v by n ( $v=v*n$ ), both values must be positive!

Ex:     assuming that C = 10 and T= 7

      \*CT             C = C \* T = 70

      \*TT             T = T <sup>2</sup> = 49

      \*C22            C = C \* 22 = 220.

➤ **With the PreCompiler**, syntax:     ***MUL v n***

Ex:     MUL C T

      MUL T T

      MUL C 22

---

|   |                   |               |  |
|---|-------------------|---------------|--|
| R | <b><i>RND</i></b> | random number |  |
|---|-------------------|---------------|--|

---

Syntax:        R

Return a pseudo random number in Z (from 0 to 4095 or >0FFF).

If you want to get n different values, compute the remainder of Z : n (remember that Z contains the remainder of every division!).

Ex:     R /Z4    return in Z random values from 0 to 3.

      R /Z26 +Z\$A    return in Z 26 different random values from 65 (code for "A") to 90 (code for "Z").

➤ **With the PreCompiler**, syntax:     ***RND***

Ex:     RND

      DIV Z 4

      RND

      DIV Z 26

      ADD Z \$A

Syntax:        **Wv**

Extend the sign of the low byte in v to a full signed word.

Ex:    =A127 WA    make A=127, no change

      =A255 WA    make A= -1, because 255 =>FF = byte -1.

This is useful when working with byte arrays if you want to work on signed integers.

➤ **With the PreCompiler, syntax:    *EXTEND***

Ex:    LET A 127  
      EXTEND A

      LET A 255  
      EXTEND A

## **Floating Point instructions**

A floating point support is provided. I have chosen to work as close as the assembler does for two reasons:

- The compiler will use less memory
- You get the best speed as no “hidden” instruction or data transfer is used.

Two float registers are always available (r0 and r1) and they are used (so modified!) by nearly every floating point instruction.

If you need to save some values, just use ‘@n instruction to reserve more registers.

---

‘@ **FARRAY** reserve float array

---

Syntax: ‘@n

Reserves space for n float registers. So, as r0 and r1 are always present, you have now access to r0, r1, r2, ..., r(n+1). Each one uses 8 bytes of memory.

If you compile several programs that need a set of floating point registers, you just have to allocate it once in the first program. Then, they all will share the same space.

*Note: if n=0, it means that you want to use the 256 bytes memory space used for the compiler labels (that is 32 registers). So you have access to r0,...,r33.*

Ex:

‘@10 : reserves 80 bytes for 10 registers r2 to r11  
‘@0 ; reserves 256 bytes for 16 registers r2 to r33.

➤ **With the PreCompiler, syntax: *FARRAY n***

Ex: FARRAY 10  
FARRAY 0

---

‘G **GETFLOAT** get float from BASIC

---

Syntax: ‘Gnm

Get a value from the CALL LINK list and stores it into r0.

n is the order of the value in the argument list.

m is 0 for a simple value or variable, or the index for an array.

Ex: with CALL LINK(“TEST”,R,FL(),-9.487)

‘G1.0 then r0 = R

‘G2.5 then r0 = FL(5)

‘G3.0 then r0 = -9.487

➤ **With the PreCompiler, syntax: *GETFLOAT n(m)***

Ex: GETFLOAT 1 (0)  
GETFLOAT 2 (5)  
GETFLOAT 3 (0)

---

‘P    **PUTFLOAT**    put float into BASIC variable

---

Syntax:        ‘Pnm

Give to a variable in the CALL LINK list the value taken from r0.

n is the order of the variable in the argument list.

m is 0 for a simple variable or the index for an array.

Ex: with CALL LINK(“TEST”,R,FL(),-9.487)

‘P1.0    R = r0

‘P2.5    FL(5) = r0

‘P3.0    error because -9.487 is not a variable!

➤ **With the PreCompiler**, syntax:    **PUTFLOAT n(m)**

Ex:    PUTFLOAT 1 (0)

        PUTFLOAT 2 (5)

        PUTFLOAT 3 (0)

---

‘M    **FMOVE**        move float registers

---

Syntax: ‘Msd

Move value of register s to register d.

Ex: ‘M0.3        then r3 = r0

‘M1.X            copies r1 into register pointed by X.

➤ **With the PreCompiler**, syntax:    **FMOVE s d**

Ex:    FMOVE 0 3

        FMOVE 1 X

---

‘+    ‘-    ‘\*    ‘/    ‘^    arithmetic

**FADD FSUB FMULFDIV FX^Y**

---

Those five instructions work the same. They use r1 and r0 and return the result in r0.  
Note that the value of r1 is lost too!

‘+        : r0 = r1 + r0    (*r1 is the lower absolute value of the two*)

‘-        : r0 = r1 - r0    (*r1 is the lower absolute value of the two*)

‘\*        : r0 = r1 \* r0    (*r1 = abs(r1)*)

‘/        : r0 = r1 / r0    (*r1=0*)

‘^        : r0 = r1 ^ r0    (*computed as exp(r0 \* log(r1) )*)

➤ **With the PreCompiler**, syntax:    **the name without parameter.**

Ex:    FADD

        FSUB

        FMUL

        FDIV

        FX^Y

---

|   |   |                      |
|---|---|----------------------|
| 'C<br><i>FCOS</i><br>'S<br><i>FSIN</i><br>'T<br><i>FTAN</i><br>'A<br><i>FATN</i><br>'Q<br><i>FSQR</i> | 'E<br><i>FEXP</i><br>'L<br><i>FLOG</i><br>'I<br><i>FINT</i><br>'N<br><i>FNEG</i><br>'B<br><i>FABS</i> | scientific functions |
|---|---|----------------------|

---

Those eight instructions work the same. They replace r0 with the result:

|                      |                   |
|----------------------|-------------------|
| 'C : r0 = cosine(r0) | 'E : r0 = exp(r0) |
| 'S : r0 = sine(r0)   | 'L : r0 = log(r0) |
| 'T : r0 = tan(r0)    | 'I : r0 = int(r0) |
| 'A : r0 = atan(r0)   | 'N : r0 = - r0    |
| 'Q : r0 = sqr(r0)    | 'B : r0 = abs(r0) |

*Note: for trigonometric functions, values are in radians.*

➤ **With the PreCompiler, syntax:** *the name without parameter.*

|          |      |
|----------|------|
| Ex: FCOS | FEXP |
| FSIN     | FLOG |
| FTAN     | FINT |
| FATN     | FNEG |
| FSQR     | FABS |

---

|     |                        |               |
|-----|------------------------|---------------|
| '?' | <b><i>FCOMPARE</i></b> | float compare |
|-----|------------------------|---------------|

---

Syntax: '?'

Compares r1 to r0, set internal flags and then you can use the IF... set of instructions. The registers r0 and r1 are not affected by the comparison.

Ex: with CALL LINK("xxx",A,B)  
 'G1.0 'M0.1 ; get A and store it in r1  
 'G2.0 '?' ; get B in r0 and compares  
 '?> x ; jump to label x if A>B.

➤ **With the PreCompiler, syntax:** *FCOMPARE*

Ex: GETFLOAT 1 (0)  
 FMOVE 0 1  
 GETFLOAT 2 (0)  
 FCOMPARE  
 IF>THEN x

---

|    |                     |  |
|----|---------------------|--|
| 'F | <b><i>FLOAT</i></b> | convert integer to floating point number |
|----|---------------------|--|

---

Syntax: 'Fn

Convert n to a floating point number and stores it into r0.

Any value that fits in a word (-32768 to 32767) can be easily used in floating point calculations.

'F1 : r0 = 1  
 'F-62 : r0 = -62  
 'FX : r0 = value stored in X



➤ **With the PreCompiler**, syntax: ***FLOAT n***

Ex: FLOAT 1  
FLOAT -62  
FLOAT X

*Note: if a constant is to be used many times (for example in a loop), you should store it in a register better than converting it each time from integer to float.*

Ex: 'F-4 ; r0 = -4  
'M0.7 ; r7 = r0, so r7 = -4

Then when you want to use -4 just recall the value of r7 in r0 or r1 (depending on the function) with:

'M7.0 or 'M7.1 because the 'M (move) instruction is faster than 'F.

➤ **With the PreCompiler**

Ex: FLOAT -4  
FMOVE 0 7  
  
FMOVE 7 0  
FMOVE 7 1

---

'Z ***INTEGER*** convert floating point number to relative integer

---

Syntax: 'Zv

Convert r0 into an integer stored in variable v.

Ex: 'F500 'Q ; r0 = 500, then take square root  
'ZS ; S = 22 (the integer part of the square root)

*Note: this conversion erases the content of r0! You must save it if the value is to be used again before using 'Z.*

➤ **With the PreCompiler**, syntax: ***INTEGER v***

Ex: FLOAT 500  
FSQR  
INTEGER S

## Joystick and Keyboard

---

|          |            |                |               |               |           |
|----------|------------|----------------|---------------|---------------|-----------|
| <b>K</b> | <b>KEY</b> | <b>KEYWAIT</b> | <b>KEYNEW</b> | read keyboard | <b>Z*</b> |
|----------|------------|----------------|---------------|---------------|-----------|

---

Syntax:        Kkn

Scan the keyboard and return a key code into the K variable.

k is a constant selecting the way the keyboard must be scanned:

- 0 returns immediately, variable K=key code or -1 if no key pressed
- 1 wait for a keypress and variable K=key code
- 2 wait for a new key press and K=key code

n is a variable or a constant:

- 0 to scan the whole keyboard
- 1 to scan left part
- 2 to scan right part

➤ **With the PreCompiler**, the instruction has been separated into three different ones:

|                  |                              |
|------------------|------------------------------|
| <b>KEY n</b>     | for K0n, returns immediately |
| <b>KEYWAIT n</b> | for K1n, wait for a key      |
| <b>KEYNEW n</b>  | for K2n, wait for a new key  |

Ex:    K0.2            scan right part and returns either key code or -1 in K.  
      K1D            scan according to D variable, wait for a key press and return the  
key code in variable K  
      KMD            bad argument error because 1<sup>st</sup> parameter is not a constant  
      Lw K1.0 CK\$Y !=w            this routine wait for a Y pressed.

➤ **With the PreCompiler**

Ex:    KEY 2  
      KEYWAIT D  
      (KMD can't be translated into PreCompiler!)

```
LABEL w
      KEY 0
      COMPARE K $Y
      IF<>THEN w
```

(\*) The comparison to zero (**Z**) tells you upon return if a key was pressed because if not, the returned value is negative, for example:

|          |                                       |
|----------|---------------------------------------|
| K0.0 ?<1 | jump to label 1 if no key was pressed |
| K0.0 !<1 | jump to label if a key was pressed    |

➤ **With the PreCompiler**

Ex:    KEY 0  
      IF<THEN 1

```
KEY 0
IF>=THEN 1
```

Syntax: Jkn

Scan the selected joystick and return button in K and move in X,Y variables.

k is a constant selecting the way the joystick must be scanned:

- 0 return immediately and fill K, X and Y, K=-1 if no button pressed
- 1 wait for button/key and fill K, X and Y
- 2 wait for a move and fill K, X and Y, K=-1 if no button pressed
- 3 wait for a move OR a button/key and fill K, X and Y, K=-1 if no button pressed
- 4 special mode: set the scale for X and Y with n value, in this case n must be a power of 2: 1, 2, 4, 8, 16, 32, 64, 128, 256... For example with J4.16 X and Y will be +/-16. Default mode is J4.4 to return +/-4 like the BASIC does.

n is a variable or a constant:

- 1 for first joystick and left part of keyboard
- 2 for second joystick and right part of keyboard
- in the special mode (k=4), n is the scale.

➤ **With the PreCompiler**, the instruction has been separated into five different ones:

|                       |   |
|-----------------------|---|
| <b>JOYST n</b>        | for J0n, returns immediately            |
| <b>JOYSTBUT n</b>     | for J1n, wait for button                |
| <b>JOYSTMOVE n</b>    | for J2n, wait for move                  |
| <b>JOYSTBUTMOVE n</b> | for J3n, wait either for button or move |
| <b>JOYSTSCALE n</b>   | for J4n set the scale                   |

Ex: J1.1 wait for a button/key pressed on joystick 1  
 J4.1 set scale to one, so X,Y will be +/-1

➤ **With the PreCompiler**

Ex: JOYSTBUT 1  
 JOYSTSCALE 4

(\*) The comparison to zero (**Z**) tells you upon return if a key was pressed because if not, the returned value is negative, for example:

J3.2 ?<c wait for a move or a key/button on joystick 2 and jump to label c if no key was pressed (so, only a movement!)  
 J2.1 !<c wait for a movement on joystick 1 and jump to label c if the button or a key was simultaneously pressed.

➤ **With the PreCompiler**

Ex: JOYSTBUTMOVE 2  
 IF<THEN c  
  
 JOYSTMOVE 1  
 IF>=THEN c

## Compare and Jump instructions

---

|   |                     |                              |
|---|---------------------|------------------------------|
| L | <b><i>LABEL</i></b> | set a label for common jumps |
|---|---------------------|------------------------------|

---

Syntax:       Lc

Make the current address marked as “c”, it can be any character, but for readability I recommend using small capitals or digits:

Any jump to “c” will transfer the program to this location.

➤ **With the PreCompiler**, syntax:    ***LABEL c***

Ex:    LABEL c

Note: when using the PreCompiler, upper case labels should not be used (from LA to LZ), they are reserved internally for pseudo-instructions.

---

|   |                    |                          |
|---|--------------------|--------------------------|
| _ | <b><i>KILL</i></b> | kill a label to reuse it |
|---|--------------------|--------------------------|

---

Syntax:       \_c

Kill the current value of label c for a later reuse.

If label c doesn't exist, there is no effect.

If label c exists and has a resolved value, then it is declared “unresolved”

If label c exists but is unresolved (this means that there are jumps to label c but no Lc encountered), this is an error! Compilation stops and “UR” error is generated.

➤ **With the PreCompiler**, syntax:    ***KILL c***

Ex:    KILL c

Note: this instruction is mostly used by the PreCompiler to manage its upper case labels for the pseudo-instructions. You should use it with care!

---

|   |                    |                   |
|---|--------------------|-------------------|
| B | <b><i>GOTO</i></b> | branch to a label |
|---|--------------------|-------------------|

---

Syntax:       Bc

Transfer the execution to label c.

➤ **With the PreCompiler**, syntax:    ***GOTO c***

---

|   |                     |                        |
|---|---------------------|------------------------|
| S | <b><i>GOSUB</i></b> | branch to a subroutine |
|---|---------------------|------------------------|

---

Syntax:       Sc

Transfer execution to label c and will return when reaching “;”.

Subroutine must start with :c (and not Lc) and end with “;”.

Only one subroutine level is allowed! This means that you can't call a subroutine from inside another subroutine.

➤ **With the PreCompiler**, syntax:    ***GOSUB c***

---

:     **SLABEL**     set a label for a subroutine

---

Syntax:         :c

Make the current address marked as “c”, it can be any character, but for readability I recommend using small capitals or digits. This becomes the entry point of a subroutine called by Sc instruction.

You must provide as many “:c” as “;” instructions (every subroutine has only one entry point and one exit point), else an error is issued.

➤ **With the PreCompiler, syntax:**     **SLABEL c**

---

;     **RETURN**     end of a subroutine

---

Syntax:         ;

Return from a subroutine.

You must provide as many “:c” as “;” instructions (every subroutine has only one entry point and one exit point), else an error is issued.

➤ **With the PreCompiler, syntax:**     **RETURN**

---

C     **COMPARE**     compare two values

---

Syntax:         Cvn

Compare v to n and then you can use the jump instructions according to the comparison.

➤ **With the PreCompiler, syntax:**     **COMPARE v n**

---

|                |                   |                   |                   |
|----------------|-------------------|-------------------|-------------------|
| ?=             | ?>                | ?<                | conditional jumps |
| <b>IF=THEN</b> | <b>IF&gt;THEN</b> | <b>IF&lt;THEN</b> |                   |

---

Syntax:         ?=c    or    ?>c    or    ?<c

Jump to label c if condition satisfied, c being a character defined by the Lc instruction.

Ex:    CAB ?=c     compare A and B and jump to c if A=B

      CA7 ?>c     compare A and 7 and jump to c if A>7

      CZ-10 ?<c    compare Z and -10 and jump to c if Z<-10

➤ **With the PreCompiler, syntax:**     **IF=THEN c   IF>THEN c   IF<THEN c**

Ex:    COMPARE A B  
      IF=THEN c

      COMPARE A 7  
      IF>THEN c

      COMPARE Z -10  
      IF<THEN c

If no other instruction is inserted, you can use more than one test on the same comparison:

CAB ?=c ?>d compare A and B and jump to c if A=B or to d if A>B

➤ **With the PreCompiler**

Ex: COMPARE A B  
IF=THEN c  
IF>THEN d

The result of each arithmetic or variable initialization is automatically compared to ZERO, so you can use a test directly (*this is not true with floating point*):

-A10 ?<c      A=A-10 and jump to c if result is negative.  
DB ?=c      decrement B by one and jump to c if B=0

➤ **With the PreCompiler**

Ex: SUB A 10  
IF<THEN c  
  
DEC B  
IF=THEN c

Instructions that perform a comparison to ZERO are marked with a “**Z**” on the right side.

---

|                       |                    |                    |                           |
|-----------------------|--------------------|--------------------|---------------------------|
| <b>!=</b>             | <b>!&gt;</b>       | <b>!&lt;</b>       | reverse conditional jumps |
| <b>IF&lt;&gt;THEN</b> | <b>IF&lt;=THEN</b> | <b>IF&gt;=THEN</b> |                           |

---

Syntax:      !=c    or    !>c    or    !<c

Jump to label c if condition not satisfied, c being a character defined by the Lc instruction.

Ex: CAB !=c      compare A and B and jump to c if A<>B  
CA7 !>c      compare A and 7 and jump to c if A<=7  
CZ-10 !<c      compare Z and -10 and jump to c if Z >= -10

➤ **With the PreCompiler, syntax:      IF<>THEN c    IF<=THEN c    IF>=THEN c**

Ex: COMPARE A B  
IF<>THEN c      <> is the same as "not ="  
  
COMPARE A 7  
IF<=THEN c      <= is the same as "not >"  
  
COMPARE Z -10  
IF>=THEN c      >= is the same as "not <"

The result of each arithmetic or variable initialization is automatically compared to ZERO, so you can use a test directly:

-A10 !<c      A=A-10 and jump to c if result is not negative (A >= 0)  
DB !=c      decrement B by one and jump to c if B <> 0

➤ **With the PreCompiler**

```
Ex:  SUB A 10
      IF>=THEN C

      DEC B
      IF<>THEN C
```

Instructions that perform a comparison to ZERO are marked with a “**Z**” on the right side.

---

|   |              |                  |          |
|---|--------------|------------------|----------|
| ( | <b>LIMIT</b> | check for limits | <b>Z</b> |
|---|--------------|------------------|----------|

---

Syntax: (lhv

Check if v is in ( l ; h ) and limit v to ( l ; h ). v must be a variable but l,h can be either variables or constants and l <= h.

The “**Z**” indicates that a comparison to ZERO is made, but in this way:  
 if v is in ( l ; h ), then considered as EQUAL that you can test with ?=, v unchanged  
 if v<l, then considered as LESS THAN, that you can test with ?<, and v=l  
 if v>h, then considered as GREATER THAN that you can test with ?>, and v=h

Ex: (10.99A ?=1 E L1 test if A is in ( 10 ; 99 ), if so, jumps to Label 1, else return to Extended Basic with E.

G1A (1.16A &SA get 1<sup>st</sup> param in A, limit A to (1,16) and use A to set screen color.

➤ **With the PreCompiler, syntax: *LIMIT l h v***

```
Ex:  LIMIT 10 99 A
      IF=THEN 1
      END
      LABEL 1

      GETPARAM 1 A
      LIMIT 1 16 A
      SCREEN A
```

---

|   |            |     |  |
|---|------------|-----|--|
| E | <b>END</b> | end |  |
|---|------------|-----|--|

---

Syntax: E  
 Return to Extended Basic.

A final E is not needed as the compiler provides one. But if your program needs another exit point, you can use “E”.

➤ **With the PreCompiler, syntax: *END***

---

[ **SELECT**    select (start a select / case / endcase structure)

---

Syntax:        [var  
Select the variable that will be compared with “%”.

Ex:            see full example at ‘%’

➤ **With the PreCompiler**, syntax:    **SELECT v**

---

%    **CASE**        case

---

Syntax:        %n or %%

Compares the selected variable to n (variable or constant) and executes the following instructions if values are equal. If you use “%%”, then it’s the default case when no other has been satisfied, it should be put in the last position!

Ex:            Imagine we’re viewing pages and the user can select “N” for next page, “P” for previous page, the page number being stored in variable P:

```
La K1.0    Label a, wait for a key and store it into K
[K        Select K
%$N    IP    case ‘N’, increment P and jump automatically after ]
%$P    DP    case ‘P’, decrement P and jump automatically after ]
%%     Ba    default for other keys, jump to Label a to read the keyboard again
]        end of select structure
...      here treat the new page!
```

➤ **With the PreCompiler**, syntax:    **CASE n        or        DEFAULT**

Ex:    LABEL a  
      KEYWAIT 0  
      SELECT K  
      CASE \$N  
          INC P  
      CASE \$P  
          DEC P  
      DEFAULT  
          GOTO a  
      ENDSELECT

**This structure can’t be nested**, this means that you can’t start a structure within another. After each case “%”, a jump to “]” is inserted so you don’t have to provide one yourself.



Optimization: if you are sure that your variable has a limited number of possible values, turn the last one into “%%” (the default case) because a case takes up 10 bytes, and default case zero bytes!

For example:

```
/A3  [Z  Z = remainder of A/3, so Z=0, 1 or 2 (no other solution!)
%0    ...here if zero...
%1    ...here if 1...
%%    ...here if 2!...
]
```

➤ **With the PreCompiler**

Ex: DIV A 3  
SELECT Z  
CASE 0  
    ...  
CASE 1  
    ...  
DEFAULT  
    ...  
ENDSELECT

---

] ***ENDSELECT***      endcase

---

Syntax:            ]  
Terminates a structure started with [var.

➤ **With the PreCompiler, syntax:    *ENDSELECT***

## Screen Instructions

---

**&**    **VDP** prefix in MLC

---

This character is a prefix before the MLC instructions concerning VDP access (such as read/write a character, set colors, music and sound...)

---

**&G**    **GETCHAR**            read a character from the screen

---

Syntax:        **&Grcv**

Return into variable **V** the ASCII code of the character found at location (r,c), r being the row (1-24) and c the column (1-32). This is CALL GCHAR(R,C,V).

Ex:    **&G1.1A**        return in A the ASCII code at position (1,1) upper left.  
      **&GR32B**        return in B the rightmost ASCII code on line R.

➤ **With the PreCompiler**, syntax:    **GETCHAR r c v**

Ex:    GETCHAR 1 1 A            or    GETCHAR (1,1) A  
      GETCHAR R 32 B           or    GETCHAR (R,32) B

---

**&P**    **PUTCHAR**            write a character on the screen

---

Syntax:        **&Prcv**

Write the character **v** at location (r,c), r being the row (1-24) and c the column (1-32). This is CALL HCHAR(R,C,V).

Ex:    **&P24.32.65**    write a "A" (65) in the lower right corner (24,32).  
      **&PRC32**        write a space " " in location (R,C).  
      **&PRC\$\***        write a "\*" in location (R,C)

➤ **With the PreCompiler**, syntax:    **PUTCHAR r c v**

Ex:    PUTCHAR 24 32 64        or    PUTCHAR (24,32) \$A  
      PUTCHAR R C 32         or    PUTCHAR (R,C) 32  
      PUTCHAR R C \$\*         or    PUTCHAR (R,C) \$\*

---

**&C**    **COLOR**            set color

---

Syntax:        **&Cgcb**

Set the color (c) and background (b) for the group g. Colors are from 1 to 16 and groups from 0 to 31, each one includes 8 characters. (Example group 8 contains characters from 64 to 71, and character Z(90) is in group 90/8 = 11).

Ex:    **&C8.1.16**        set group 8 (starting at character 64) to black (1) on white (16).

➤ **With the PreCompiler**, syntax:    **COLOR g c b**

Ex:    COLOR 8 1 16



➤ **With the PreCompiler**, syntax: *DEFCHAR pic*

```
Ex:  GETPARAM 1 C
      GETPARAM 2 I
      DEFCHAR 3 (I) C
```

If C=65 (code for A) and I=1 then this will use A\$(1) to redefine “A”

If C=65 and I=2 this will use A\$(2) to redefine both “A” and “B” because A\$(2) contains definition for two characters!

If C=48 (code for 0) and I=3, this will use A\$(3) to redefine “0”, “1”, “2” and “3” because A\$(3) contains definition for four characters!

---

&d ***XDEFCHAR*** set character definition in extended zone

---

Syntax: &dpic

Works the same as DEFCHAR (&D) but in extended zone, see *Pattern discussion* in the next section.

---

&X ***XPATTERN*** extended pattern definitions

---

Syntax : &Xn

Moves either the character definitions or the sprites definitions or both to a new zone to have more characters available.

n = 0 : normal mode as in Extended Basic

n = 1 : characters don't move but sprites can have 256 new definitions

n = 2 : sprites don't move but you can have 256 new characters

n = 3 : both move to a common new zone for 256 definitions

### **Pattern discussion:**

For a set of 256 characters, you need a  $256 \times 8 = 2048$  bytes bloc. The Extended Basic (XB) has defined this zone at address zero in VDP Ram. But, to free more memory for BASIC, other zones overwrite part of this bloc (the screen, colors tables, sprite tables...). That's why you can define freely characters from 32 to 143 but you don't have access to the other.

Another problem came: for example, character 32 (the space) is defined from address 256 to 263 ( $32 \times 8$  to  $32 \times 8 + 7$ ). But these addresses are included into the screen memory! So, Texas decided to internally add an offset of 96 to every ASCII character.

Actually, when a space appears on the screen, it is the character  $96 + 32 = 128$  that is in memory. When character 143 appears, it is actually the character  $143 + 96 = 239$ .

*(You don't have to manage this as XB does it for you. The same for MLC with instructions GETCHAR, PUTCHAR, SPATTERN, DEFCHAR: they all add 96 when writing a byte or subtract 96 when reading it.)*

What XPATTERN offers is to change the position of the patterns table in memory to give access to more char definitions without overwriting the other important tables:

### **XPATTERN 1 (&X1)**

The characters are still in the standard zone, so 112 of them are redifinable, but for the Sprites, you have now access to a new table of 256 characters.

To define a character for sprite in the new zone, use XDEFCHAR (&d), the char number can be from 0 to 255 and no offset is applied neither by XDEFCHAR (&d) nor by SPATTERN (#A).

### **XPATTERN 2 (&X2)**

The Sprites remain in the standard zone (112 characters) but the characters are moved to a new zone with 256 new patterns available. To define a character in the new zone, use XDEFCHAR (&d), the char number can be from 0 to 255 and no offset is applied neither by GETCHAR (&G) nor by PUTCHAR (&P).

### **XPATTERN 3 (&X3)**

Both sprites and characters are moved to this common zone of 256 new characters. To define a character or a sprite in the new zone, use XDEFCHAR (&d), the char number can be from 0 to 255 and no offset is applied neither by GETCHAR (&G) nor by PUTCHAR (&P) or SPATTERN (#A).

### **XPATTERN 0 (&X0)**

To return to XB, you should reset the standard addresses. This is not safe as the new pattern zone may conflict with XB data. But, if your program don't use too much strings or arrays, this should be okay.

Note: See at "*F18A Support*" for use of XPATTERN with the new graphic modes.

### **Memory usage (MLC):**

A 256 bytes zone is available at run time to the user through two instructions: **TR** for table reservation and ``@` for floating point array. The **&D** and **&d** instructions use the last 33 bytes for string transfer!

So, if you used TRA0 for word array, then A(0) to A(110) are available but A(111) to A(127) are lost.

If you used TRE0 for byte array, then E(0) to E(222) are available but E(223) to E(255) are lost.

If you used ``@0` for floating point array, then R2 to R28 are available, but R29 to R33 are lost.

### **Memory usage (PreCompiler):**

A 256 bytes zone is available at run time to the user through two instructions: **DIMTABLE** for table reservation and **FARRAY** for floating point array. The **DEFCHAR** and **XDEFCHAR** instructions use the last 33 bytes for string transfer!

So, if you used DIMTABLE A 0 for word array, then A(0) to A(110) are available but A(111) to A(127) are lost.

If you used DIMTABLE E 0 for byte array, then E(0) to E(222) are available but E(223) to E(255) are lost.

If you used FARRAY 0 for floating point array, then R2 to R28 are available, but R29 to R33 are lost.

## **Sprites**

There are various differences between the Basic and Assembly codes for sprites. But My Little Compiler does the conversion and you program them like you would do with the Extended Basic, so:

28 available sprites numbered from 1 to 28 (0 to 31 in assembly)

Row position from 1 to 192 (-1 to 190 in assembly)

Column position from 1 to 256 (0 to 255 in assembly)

---

# Sprite prefix

---

This is the prefix character for all sprite instructions in MLC.

---

#A ***SPATTERN*** change sprite pattern

---

Syntax: #Asc

Set character c for sprite s (see ***&X***, ***XPATTERN*** for extended characters)

Ex: #A1\$\* set character "\*" for sprite 1

➤ **With the PreCompiler**, syntax: ***SPATTERN s c***

Ex: SPATTERN 1 \$\*

---

#C ***SCOLOR*** change sprite color

---

Syntax: #Csc

Set color c for sprite s.

Ex: #C3.16 set color 16 (white) for sprite 3.

➤ **With the PreCompiler**, syntax: ***SCOLOR s c***

Ex: SCOLOR 3 16

---

#L ***SLOCATE*** locate or create a sprite

---

Syntax: #Lsrc

Put the sprite s at position (r,c). s,r,c can be either constants or variables.

Ex: #L1AB put sprite 1 at location (A,B)

#L3.1.1 put sprite 3 in the upper left corner of the screen.

➤ **With the PreCompiler**, syntax: ***SLOCATE s r c***

Ex: SLOCATE 1 A B or SLOCATE 1 (A,B)  
SLOCATE 3 1 1 or SLOCATE 3 (1,1)

If the sprite is created with this function, you must specify before its color and pattern, so a complete creation would be:

#A1\$F #C1.16 #L1.100.100 ; create sprite 1, pattern F, white at (100,100)

---

#M **SMOTION** set sprite motion

---

Syntax: #Msrc

Set the automatic motion of sprite s to (r,c) values are from -128 to +127.

➤ **With the PreCompiler**, syntax: **SMOTION s r c**

Ex: SMOTION s r c or SMOTION s (r,c)

---

#P **SPOSITION** get sprite position

---

Syntax: #Psrc

Get the position of sprite s and return it into r and c. R and c must be variables and s can be either a variable or a constant.

Ex: #P3AB get position of sprite 3 and put row in A, column in B.

➤ **With the PreCompiler**, syntax: **SPOSITION s r c**

Ex: SPOSITION 3 A B or SPOSITION 3 (A,B)

---

#& **SCONVERT** convert coordinates

---

Syntax: #&rc

Convert coordinates of a sprite (1-192/1-256) to a character location (1-24/1-32).

Note: *previous values of variables r and c are lost!*

Ex: #P1AB #&AB &GABC put in A,B the position of sprite #1, convert them and then get in C the character under that location.

➤ **With the PreCompiler**, syntax: **SCONVERT r c**

Ex: SPOSITION 1 (A,B)  
SCONVERT (A,B)  
GETCHAR (A,B) C

---

#D **SDISTANCE** sprite distance

---

Syntax: #Dss'v

Compute the distance between sprites s and s' and return it in v. V must be a variable and s/s' can be either variables or constants.

➤ **With the PreCompiler**, syntax: **SDISTANCE s s' v**

The distance is not the cartesian one, but an approximation with a faster algorithm (*the difference can be up to 7,7% with a mean value of 4,8%*).

Details: Assuming that Sprite s is at (x1,y1) and s' at (x2,y2)

$$\Delta x = |x1 - x2| \quad \Delta y = |y1 - y2|$$

$$M = \max(\Delta x, \Delta y) \quad \text{and} \quad N = \min(\Delta x, \Delta y)$$

$$Dist = (5M + 2N) / 5$$

---

|           |                         |                                       |
|-----------|-------------------------|---------------------------------------|
| <b>#I</b> | <b><i>INTERRUPT</i></b> | enable interrupt for automatic motion |
|-----------|-------------------------|---------------------------------------|

---

Syntax:       #I

Insert assembly instructions that allows VDP interrupt to automatically move the sprites when they have a motion defined. This “#I” must be regularly inserted in your routine else, sprites won’t move smoothly.

For example if you have a long “wait” loop, then put #I in it.

To ease your work, My Little Compiler automatically insert #I into every K and J instruction (wait for Key or Joystick) as soon as a #I instruction is encountered. So if your loop includes J or K, just put one #I before the loop and that’s it, interrupts will work.

➤ **With the PreCompiler, syntax:**       ***INTERRUPT***

Note: *Even if your sprites are yet in motion from Extended Basic you have to use #I to allow your sprites to move as CALL LINK disables the interrupts.*

---

|           |                       |                 |
|-----------|-----------------------|-----------------|
| <b>#K</b> | <b><i>SDELETE</i></b> | delete a sprite |
|-----------|-----------------------|-----------------|

---

Syntax:       #Ks

Delete sprite s in the same manner as the Extended Basic would do (for compatibility). This means that its motion is set to (0,0) and its position to [194,1] (*this is [192,0] in VDP RAM.*). Therefore, motion and position are lost, but pattern and color preserved if you have to create it again.

➤ **With the PreCompiler, syntax:**       ***SDELETE s***

---

|              |                    |   |
|--------------|--------------------|---|
| <b>#&lt;</b> | <b><i>SMAX</i></b> | set the maximum number of sprites in motion |
|--------------|--------------------|---|

---

Syntax:       #<n

Tells the system that sprites 1 to n can automatically move. If n=0 then they all are stopped.

If n is greater than previous value, then new moving sprites have their motion set to zero, so #M must be used after #<.

If n is lower than previous value, then excluded sprites are stopped and their motion lost.

Ex:   #<5           tells the system that sprites 1 to 5 can move  
       #<0           stop every sprite  
       #<A           takes value from A to set the maximum sprite # to be in motion.

➤ **With the PreCompiler, syntax:**       ***SMAX n***

Ex:   SMAX 5  
       SMAX 0  
       SMAX A



Note: *If your sprites are yet in motion when calling CALL LINK, you don't have to use this instruction as the Extended Basic has correctly set up things. Use it to modify the state! (Add new sprites in motion, or remove moving sprites).*

## Logical instructions

---

H     Logical prefix

---

This is the prefix character for all logical instructions in MLC (*Why H? No other interesting letter was free...*)

---

HA    **AND**            logical AND

---

Syntax: HAVn

Performs a logical AND between variable V and value n (constant or variable). Bits are set to “1” if they are both to “1” in V and in n.

➤ **With the PreCompiler**, syntax:    **AND v n**

---

HO    **OR**                logical OR

---

Syntax: HOVn

Performs a logical OR between variable V and value n (constant or variable). Bits are set to “1” if they are to “1” in V or/and in n.

➤ **With the PreCompiler**, syntax:    **OR v n**

---

HX    **XOR**                logical XOR

---

Syntax: HXVn

Performs a logical XOR between variable V and value n (constant or variable). Bits are set to “1” if they are different in V and in n.

➤ **With the PreCompiler**, syntax:    **XOR v n**

---

HN    **NOT**                logical NOT

---

Syntax: HNV

Performs a logical NOT into variable V. Bits are changed from “1” to “0” or from “0” to “1”.

➤ **With the PreCompiler**, syntax:    **NOT v**

---

|    |                      |            |
|----|----------------------|------------|
| HW | <b><i>SBYTES</i></b> | swap bytes |
|----|----------------------|------------|

---

Syntax: HWV

Swap bytes into variable V. The most significant byte and the less significant byte are exchanged.

➤ **With the PreCompiler**, syntax: ***SBYTES v***

---

|    |                       |                               |
|----|-----------------------|-------------------------------|
| H< | <b><i>SHIFTLA</i></b> | logical SHIFT LEFT ARITHMETIC |
|----|-----------------------|-------------------------------|

---

Syntax: H<Vn

Shift bits in variable V n positions to the left. Empty bits are “0”

➤ **With the PreCompiler**, syntax: ***SHIFTLA v n***

---

|    |                       |                                |
|----|-----------------------|--------------------------------|
| H> | <b><i>SHIFTRA</i></b> | logical SHIFT RIGHT ARITHMETIC |
|----|-----------------------|--------------------------------|

---

Syntax: H>Vn

Shift bits in variable V n positions to the right. Empty bits are “0” or “1” according to the sign of V before shifting.

➤ **With the PreCompiler**, syntax: ***SHIFTRA v n***

---

|    |                       |                             |
|----|-----------------------|-----------------------------|
| HL | <b><i>SHIFTRL</i></b> | logical SHIFT RIGHT LOGICAL |
|----|-----------------------|-----------------------------|

---

Syntax: HL Vn

Shift bits in variable V n positions to the right. Empty bits are “0”.

➤ **With the PreCompiler**, syntax: ***SHIFTRL v n***

---

|    |                       |                      |
|----|-----------------------|----------------------|
| HR | <b><i>ROTATER</i></b> | logical ROTATE RIGHT |
|----|-----------------------|----------------------|

---

Syntax: HR Vn

Rotate bits in variable V n positions to the right.

➤ **With the PreCompiler**, syntax: ***ROTATER v n***

---

|    |              |                      |
|----|--------------|----------------------|
| HC | <b>CARRY</b> | get last "CARRY" bit |
|----|--------------|----------------------|

---

Syntax: HC

Store in Z the last CARRY bit from a Shift/Rotate instruction.

For SHIFT instructions, this is the last lost bit.

For ROTATE, this is the last bit to change from right to left.

So, Z=0 or Z=1.

➤ **With the PreCompiler, syntax:    **CARRY****

*Note: this instruction must be as close as possible to the last shift/rotate instruction because the carry bit is stored into a temporary register that can be overwritten!*

## Set instructions

---

F      set prefix

---

This is the prefix character for all set instructions in MLC.

---

FD    *DIMSET*                  dimension of a set

---

Syntax:      FDnmV

Create an empty set that can contain values from n to m (both must be constants) and returns the address of the set in variable V.

In the set, every element is a single bit (0 if absent, 1 if present in the set).

➤ **With the PreCompiler**, syntax:    *DIMSET (n,m) v*

Memory usage: a set requires 3 words plus one bit per element.

For example, with FD5.80A there are 76 elements, so 76 bits required, but the memory is word aligned so MLC will use 80 bits (5\*16).

Finally:  $3 * 2$  (because words) +  $80 / 8 = 16$  bytes used.

---

F+    *ELEMENT+*                add an element in the set

---

Syntax:      F+Vn

Add element n into set pointed by V.

If the element is already in V, then nothing happens.

If n is outside the range specified when creating the set, this can lead to an unpredictable behaviour.

➤ **With the PreCompiler**, syntax:    *ELEMENT+ v n*

---

F-    *ELEMENT-*                remove an element from the set

---

Syntax:      F-Vn

Remove element n from set pointed by V.

If the element is not in V, then nothing happens.

If n is outside the range specified when creating the set, this can lead to an unpredictable behaviour.

➤ **With the PreCompiler**, syntax:    *ELEMENT- v n*

---

|    |                 |   |          |
|----|-----------------|---|----------|
| F? | <b>ELEMENT?</b> | test the presence an element in the set | <b>Z</b> |
|----|-----------------|---|----------|

---

Syntax: F?Vn

Test if n is into set pointed by V.

If the element is in, then "equality" (you can test it with ?=...)

If the element is not in the set, then "no equality" (you can test this with !=...).

If n is outside the range specified when creating the set, this can lead to an unpredictable behaviour.

- **With the PreCompiler**, syntax: **ELEMENT? v n**

---

|    |                |              |  |
|----|----------------|--------------|--|
| FO | <b>SETFILL</b> | fill the set |  |
|----|----------------|--------------|--|

---

Syntax: FOV

Fill set pointed by variable V.

All elements are added, the set is filled with ones.

- **With the PreCompiler**, syntax: **SETFILL v**

---

|    |                 |               |  |
|----|-----------------|---------------|--|
| FZ | <b>SETCLEAR</b> | clear the set |  |
|----|-----------------|---------------|--|

---

Syntax: FZV

Clear set pointed by variable V.

All elements are removed, the set is filled with zeros.

- **With the PreCompiler**, syntax: **SETCLEAR v**

---

|    |                |                       |  |
|----|----------------|-----------------------|--|
| FN | <b>SETCOMP</b> | complement of the set |  |
|----|----------------|-----------------------|--|

---

Syntax: FNV

Change the set pointed by variable V to its complement.

All elements that were not included are now included, all elements that were included are now removed. Zeros and ones are exchanged.

- **With the PreCompiler**, syntax: **SETCOMP v**

---

|    |                |                     |          |
|----|----------------|---------------------|----------|
| FC | <b>SETCARD</b> | cardinal of the set | <b>Z</b> |
|----|----------------|---------------------|----------|

---

Syntax: FCVV'

Count the number of elements in the set pointed by variable V and returns the value into variable V'.

- **With the PreCompiler**, syntax: **SETCARD v v'**

---

|    |                    |                              |          |
|----|--------------------|------------------------------|----------|
| FF | <b>SETFINDNEXT</b> | find next element in the set | <b>Z</b> |
|----|--------------------|------------------------------|----------|

---

Syntax: FFVV'

Find the next element in the set pointed by variable V starting at element V'.

If found: return "equality" and value in V' (so you can use ?=...)

If not found: return "no equality" and V' remains unchanged (so you can use !=...)

Example: FD3.10A so A is a set of [3,10].

F+A4 F+A8 add elements 4, 8

=B3

FFAB find next element starting at 3, so B=4 and "equality"

?=c so it will jump to label c

=B5

FFAB find element starting at 5, so B=8 and "equality"

=B9

FFAB nothing to find, so returns "no equality"

!=c so it will jump to label c

➤ **With the PreCompiler**, syntax: **SETFINDNEXT v v'**

Ex: DIMSET (3,10) A  
ELEMENT+ A 4  
ELEMENT+ A 8

LET B 3  
SETFINDNEXT A B  
IF=THEN c

LET B 5  
SETFINDNEXT A B

LET B 9  
SETFINDNEXT A B  
IF<>THEN c

---

|    |             |                   |
|----|-------------|-------------------|
| FU | <b>SET+</b> | union of two sets |
|----|-------------|-------------------|

---

Syntax: FUVV'

Computes the union of the two sets, V=V union V'

So V contains the elements that were in V or in V'.

➤ **With the PreCompiler**, syntax: **SET+ v v'**

Note: V and V' must have the same definition.

---

|    |             |                          |
|----|-------------|--------------------------|
| FI | <b>SET*</b> | intersection of two sets |
|----|-------------|--------------------------|

---

Syntax: FIVV'

Computes the intersection of the two sets,  $V = V \text{ inter } V'$

So V contains the elements that were both in V and in V'.

➤ **With the PreCompiler**, syntax: **SET\* v v'**

Note: V and V' must have the same definition.

---

|    |             |                        |
|----|-------------|------------------------|
| FX | <b>SET-</b> | difference of two sets |
|----|-------------|------------------------|

---

Syntax: FXVV'

Computes the difference of the two sets,  $V = V - V'$

So V contains the elements that were in V but not in V' (in other words, this removes from V the elements that were in V').

➤ **With the PreCompiler**, syntax: **SET- v v'**

Note: V and V' must have the same definition.



## **Music, Sound, Speech**

Sounds must be prepared through the SOUND section before you run your own assembly routine that will use them. It's a kind of "compilation" because you will write strings describing your sound that "My Little Compiler" will turn into binary codes that the sound processor can understand. The Extended Basic does the same from a CALL SOUND statement to binary codes.

Those codes must be located into VDP RAM, so, the easiest solution I found is to store them into a string array, each string storing a sound, so the sound number is limited only by the amount of free memory for your strings. The sound section is compiled with the other sections using this call:

Syntax: **CALL LINK ("COMPIL", IO(), S\$( ), C\$( ))**

Then the S\$( ) array can be passed to your assembly routine that will play them using the "&M" function, the S\$( ) array **must be the first parameter** in the CALL LINK statement.

An example:

```
DATA S ; start a sound section
DATA "2" ; store binary codes in string S$(2) (*)
DATA "FA261VA2D30" ; On voice A play a C (261 Hz) with volume 2 and 30/60 sec
DATA "FA392D15" ; On voice A play a G (392 Hz) same volume and 15/60 sec
DATA "VA15D0" ; shut down sound (volume 15 = no sound)
DATA "" ; end
```

(\*) Note that with :

```
DATA "2T" the sound is tested so you can hear it during this compilation.
```

Then I can use the &M function into my assembly routine to play this sound #2. If so, in the parameter list, the S\$( ) array must be the first parameter.

```
CALL LINK ("MYASM", S$( ), ...)
```

---

|               |              |                   |                  |                         |
|---------------|--------------|-------------------|------------------|-------------------------|
| <b>&amp;M</b> | <b>SOUND</b> | <b>SOUNDQUEUE</b> | <b>SOUNDWAIT</b> | play a music or a sound |
|---------------|--------------|-------------------|------------------|-------------------------|

---

Syntax:        &Mkn

Play sound n with mode k. Both can be either constant or variables.

k determines how the sound is played:

- k=0 don't wait for previous sound to stop, play this one and execute next instruction immediately.
- k=1 wait for previous sound to stop, then play this one and execute next instruction immediately.
- k=2 wait for previous sound to stop, play this one and wait until it is finished before executing next instruction.

n represents the index of the string containing the sound in the array passed as **the first argument** in the CALL LINK statement.

Example:        CALL LINK("TEST",S\$(...))

      &M0.3        play sound stored into S\$(3) and don't wait

      =V10 &M2V   play sound stored into S\$(10) and wait before going on.

➤ **With the PreCompiler**, the instruction has been separated in three different ones:

**SOUND n**                                for    &M0n, play immediately

**SOUNDQUEUE n**                        for    &M1n, wait and play

**SOUNDWAIT n**                         for    &M2n, wait, play and wait

Ex:    SOUND 3  
      LET V 10  
      SOUNDWAIT 2 V

Interrupts must be enabled in order to play sound correctly, the same problem as with the sprite automatic motion. So you must provide a **#I** (or **INTERRUPT** with the PreCompiler) instruction regularly knowing that:

- wait on keyboard and joystick contain their own interruption instructions if one #I has been met before
- wait on sound end (&M1n and &M2n) does the same.

So regular #I are to be used if no joystick, nor keyboard, neither sound waits are performed.

Let's return to the sound compilation...

### **Sound description:**

Your TI-99 is able to produce three tones (voices A,B and C) and one noise (voice N) simultaneously. Each voice can have its own frequency (from 110 Hz to 55938 Hz for tones and 1 to 8 for noises). Each voice can have its own volume (0 high, 14 low, 15 OFF).

When sounds are simultaneous, only one duration must be provided, it is in 60<sup>th</sup> of seconds (from 0 to 255). For example D=30 is half a second, and max value is D=255 for 4,25 seconds.

So the sound description is a list of groups each one with frequencies, volumes and one duration.

#### The general form of a group:

“frequency informations volume informations duration”

Frequency informations start with a “F” and then you specify each voice (A,B,C or N) followed by its frequency (from 110 to 55938):

Ex: FA220C440

Volume informations start with a “V” and then you specify each voice (A,B,C or N) followed by its volume (from 0 to 15):

Ex: VA1C5

Duration information start with a “D” followed by the duration in 60<sup>th</sup> of second (from 0 to 255):

Ex: D10

A complete group can be:

FA220C440VA1C5D10

If, from one group to the next, the frequency doesn't change, you just have to provide the volumes informations, example:

|            |   |
|------------|---|
| FA440VA0D2 | * a A with high volume                                |
| VA2D3      | * decrease volume                                     |
| VA4D4      | * but increase duration                               |
| VA6D5      | * this gives a note slowly decreasing                 |
| VA8D6      |   |
| VA12D7     |   |
| VA14D8     |   |
| VA15D0     | * stop voice A with both volume = 15 and duration = 0 |

In the same way, if volume doesn't change, you just have to provide frequencies from one group to another:

FA440VA0D10      \* a A with high volume  
FA554D10          \* a C# with same volume  
FA659D20          \* a E with same volume  
VA15D0            \* stop sound

Important: *what you can't omit is the duration that validates a group.*

Not less important: don't forget to **stop the sound** with **volumes at 15** for each voice used and **duration at zero**.

➤ **With the PreCompiler**, the previous sounds could be defined as:

Ex:

```
$SND 1            ; this will be sound 1 in S$(1), use with SOUND 1  
FA440VA0D2 VA2D3 VA4D4 VA6D5  
VA8D6 VA12D7 VA14D8 VA15D0  
$$  
$SND 2            ; this will be sound 2 in S$(2), use with SOUND 2  
FA440VA0D10 FA554D10  
FA659D20 VA15D0  
$$
```

---

&T    **SAY**                    say rom word

---

Syntax:            &Tn  
n is the ROM address of a word into the Speech Synthesizer memory.

Example: &T13594            will say HELLO (13594 =>351A address for hello)

➤ **With the PreCompiler**, syntax        **SAY n**

Ex:    SAY 13594  
      SAY &h351A            ; same address but in hexadecimal  
      SAY &wHELLO          ; same address but by word directly !

Note: The PreCompiler knows all the standard vocabulary of the Speech unit. Some contain several words, like TEXAS INSTRUMENTS, you can't use the space, you must replace it with an underscore:

```
SAY &wTEXAS_INSTRUMENTS
```

---

**&? TALKING?** is talking?

---

Syntax: &?

Returns “=” if the unit is talking (so you have to wait before saying another word)

Returns “<>” if the unit is ready for another word.

Example:

```
&T13594          ; say HELLO
Lx &? ?=x        ; wait loop until <>
&T29118          ; say YOU
```

➤ **With the PreCompiler, syntax TALKING?**

```
Ex: SAY &wHELLO          or          SAY &wHELLO
    LABEL x              REPEAT
        TALKING?          TALKING?
    IF=THEN x            UNTIL<>
    SAY &wYOU            SAY &wYOU
```

---

**&U SAYUSER** say user word

---

Syntax: &Unc

If c=1 then n is the even CPU address of the data starting with a word containing the number of bytes to send to the Speech unit.

If c=-1 then n is the VDP address of the data and Z must contain the number of bytes (*this organization to be coherent with the TG instruction when receiving a string address*).

```
Example: with          CALL SPGET(“TWENTY”,T$)
                      CALL LINK(“TEST”,T$)
=U1                   ; to get the first parameter
TGU0A                 ; A=vdp string address and Z=string length
&UA-1                 ; say the word “TWENTY” from vdp ram.
```

➤ **With the PreCompiler, syntax SAYUSER n c**

```
Ex: LET U 1
    TABLEGET U(0) A
    SAYUSER A -1
```

## **File access**

The TI-99/4A always uses the VDP ram for file transfers. Two zones are necessary:

- The data bloc where bytes read from or written to the file are stored
- The PAB (peripheral access bloc) that describes the file and the operations to perform

### *PAB discussion*

This is a bloc with 10 bytes plus the file name you have to create in VDP Ram. Some operations don't use every entry, you have to fill every useful entry yourself except the OpCode that is sent with the instruction:

|        |                      |  |
|--------|----------------------|--|
| BYTE   | <b>OpCode</b>        | <i>File operation (0 to 9), see below</i>                              |
| BYTE   | <b>flags</b>         | <i>See below</i>   |
| WORD   | <b>Data Address</b>  | <i>Address of data bloc in VDP Ram</i>                                 |
| BYTE   | <b>Record length</b> | <i>For fixed files or max length for variable files</i>                |
| BYTE   | <b>Count</b>         | <i>In input for FWRITE/FREAD and in output for FREAD</i>               |
| WORD   | <b>Record number</b> | <i>For relative files or size for FSAVE/FLOAD</i>                      |
| BYTE   | <b>Screen Offset</b> | <i>Used for cassette operations (&gt;60 for BASIC, &gt;00 for E/A)</i> |
| BYTE   | <b>Name length</b>   |  |
| STRING | <b>Name</b>          | <i>Ex: DSK1.MYFILE or CSI</i>  |

### *Flags:*

This is the sum of different values to describe the file:

|                   |    |  |
|-------------------|----|--|
| <b>SEQUENTIAL</b> | 0  | <i>Sequential access to the file</i>                             |
| <b>RELATIVE</b>   | 1  | <i>Access with Record Number</i>                                 |
| <b>UPDATE</b>     | 0  | <i>Read and write allowed</i>                                    |
| <b>OUTPUT</b>     | 2  | <i>Only write allowed</i>  |
| <b>INPUT</b>      | 4  | <i>Only read allowed</i>   |
| <b>APPEND</b>     | 6  | <i>Add data to the end of the file but you can't read</i>        |
| <b>DISPLAY</b>    | 0  | <i>Data are displayable chars, a text file for example</i>       |
| <b>INTERNAL</b>   | 8  | <i>Data are binary bytes, a character definition for example</i> |
| <b>FIXED</b>      | 0  | <i>Fixed record length</i>                                       |
| <b>VARIABLE</b>   | 16 | <i>Variable record length</i>                                    |

For example, to write to a text file, I select:

$$\text{SEQUENTIAL} + \text{OUTPUT} + \text{DISPLAY} + \text{VARIABLE} = 0 + 2 + 0 + 16 = 18.$$

If I want to read sequentially binary data in blocs of 32 bytes:

$$\text{SEQUENTIAL} + \text{INPUT} + \text{INTERNAL} + \text{FIXED} = 0 + 4 + 8 + 0 = 12.$$

- See **FLAGS** in the **Pseudo-Instruction** chapter to ease the operation

### ***Error codes:***

After a file operation, the Flags byte also contains an error code or zero, you don't have to manage this as MLC returns automatically the error code into Z.

|          |  |
|----------|--|
| <b>0</b> | <i>No error</i>  |
| <b>1</b> | <i>Device is write protected</i>   |
| <b>2</b> | <i>Open error: flags don't match the file</i>                                    |
| <b>3</b> | <i>Illegal operation (not supported by device or don't match the Open flags)</i> |
| <b>4</b> | <i>Out of table or buffer space on the device</i>                                |
| <b>5</b> | <i>Read after file end, this closes the file.</i>                                |
| <b>6</b> | <i>Hardware device error.</i>  |
| <b>7</b> | <i>File error (prog/data mismatch, read from a non existing file...)</i>         |
| <b>8</b> | <i>Bad device name</i>   |

### **Where to locate the PAB and Data bloc?**

Extended Basic uses part of VDP Ram to store the variables names and variables values (strings, numbers, arrays...). There is a pointer at address >831A containing the VDP address of the string/variables blocs. Under this address, the Ram should be free, but take care not to overwrite the char definitions, the sprites and screen.

#### **1) With the PreCompiler**

Example, you want to access to a text file with a maximum length of 80 chars:

```
STARTDATA
  BYTE 0          ; no OpCode for now
  FLAGS SEQUENTIAL, DISPLAY, VARIABLE, INPUT
  WORD 0          ; address will be computed later
  BYTE 80         ; max length
  BYTE 80         ; length
  WORD 0          ; no rec number for sequential
  BYTE 0          ; offset unused
  BYTE 11         ; name is 11 bytes long
  STRING "DSK1.MYTEXT"
ENDDATA A

LET B &h831A
GETTABLE B(0) B   ; peek(831A) = VDP address

SUB B 22          ; place for PAB so B = PAB ADDRESS
LET C B
SUB C 80          ; place for one string, C = DATA ADDRESS
PUTTABLE A(1) C  ; data address stored into PAB (i.e word A(1))
BMOVECTOV A 22 B ; copy PAB to VDP Ram
```

That's all for initialization, then you can use the file instructions with B as PAB address such as:

```
FOPEN B    to open the file
FREAD B    to read from the file
Etc...
```

## 2) With MLC

```
BA T<      ; jump over table and keep bloc address
TO0        ; no Opcode for now
TO20       ; sequential, display, variable, input
TT0        ; address will be computed later
TO80       ; max length
TO80       ; length
TT0        ; no rec number for sequential
TO0        ; offset unused
TO11       ; name is 11 bytes long
TS11DSK1.MYTEXT
TE         ; ensure even address
LA T>A     ; get bloc address in A
=B-31974   ; B=>831A
TGB0B     ; peek B into B
-B22      ; B=B-22 to get place for PAB
=CB
-C80      ; C=PAB-80 to get place for string
TPA1C     ; store C into data address of PAB (i.e word A(1))
TCA22B    ; copy PAB to VDP Ram
```

That's all for initialization, then you can use the file instructions with B as PAB address such as:

```
Y0B    to open the file
Y2B    to read from the file.
Etc...
```

## ***Ram conflicts...***

When you get back to Extended Basic, the interpreter may use the RAM where you put you PAB and Data Bloc. So, don't expect to find it again when back in MLC. The safer is to create a PAB in CPU Ram and to copy it to VDP Ram each time you get into your assembly program using the >831A pointer.



---

|    |              |             |          |
|----|--------------|-------------|----------|
| Y0 | <b>FOPEN</b> | open a file | <b>Z</b> |
|----|--------------|-------------|----------|

---

Syntax:      Y0n            or            **FOPEN n**

Open the file whose PAB is at address n (constant or variable). Return the error code in Z.

**Input:**            Flag, Record length, Name

**Output:**          If Record Length=0 in input, returns the Record length of the file.

---

|    |               |              |          |
|----|---------------|--------------|----------|
| Y1 | <b>FCLOSE</b> | close a file | <b>Z</b> |
|----|---------------|--------------|----------|

---

Syntax:      Y1n            or            **FCLOSE n**

Close the file whose PAB is at address n (constant or variable). Return the error code in Z.

**Input:**            Flag, Name

**Output:**          In OUTPUT or APPEND mode, an EOF record is written.

---

|    |              |                  |          |
|----|--------------|------------------|----------|
| Y2 | <b>FREAD</b> | read from a file | <b>Z</b> |
|----|--------------|------------------|----------|

---

Syntax:      Y2n            or            **FREAD n**

Read a bloc of bytes from the file whose PAB is at address n (constant or variable). Return the error code in Z.

**Input:**            Flag, Data Address, Record length, Name, Record Number (if relative)

**Output:**          Count is filled with the actual bytes read.

---

|    |               |                 |          |
|----|---------------|-----------------|----------|
| Y3 | <b>FWRITE</b> | write to a file | <b>Z</b> |
|----|---------------|-----------------|----------|

---

Syntax:      Y3n            or            **FWRITE n**

Write a bloc of bytes to the file whose PAB is at address n (constant or variable). Return the error code in Z.

**Input:**            Flag, Data Address, Record length, Name, Record Number (if relative)  
Count (is the number of bytes to write)

**Output:**          None.

---

|    |                        |                   |          |
|----|------------------------|-------------------|----------|
| Y4 | <b><i>FRESTORE</i></b> | set file position | <b>Z</b> |
|----|------------------------|-------------------|----------|

---

Syntax:      Y4n                  or                  ***FRESTORE n***

Set position into the file whose PAB is at address n (constant or variable). Return the error code in Z.

If sequential, the pointer is restored at the beginning of the file.

If relative, the pointer is restored at the Record Number specified.

**Input:**              Flag, Record length, Name, Record Number (if relative)

**Output:**            The pointer is positioned as indicated.

Note: *FRESTORE works only for INPUT or UPDATE modes. With a relative file, you can simulate a FRESTORE by filling Record Number for any other operation even with OUTPUT and APPEND modes.*

---

|    |                     |             |          |
|----|---------------------|-------------|----------|
| Y5 | <b><i>FLOAD</i></b> | load a file | <b>Z</b> |
|----|---------------------|-------------|----------|

---

Syntax:      Y5n                  or                  ***FLOAD n***

Read the whole file whose PAB is at address n (constant or variable). Return the error code in Z.

**Input:**              Data Address, Name, Record Number (is the number of bytes to read)

**Output:**            The Data Bloc is filled with the whole file (limited by Rec Num)

Note: *no previous FOPEN operation is needed.*

---

|    |                     |                |          |
|----|---------------------|----------------|----------|
| Y6 | <b><i>FSAVE</i></b> | save to a file | <b>Z</b> |
|----|---------------------|----------------|----------|

---

Syntax:      Y6n                  or                  ***FSAVE n***

Write a bloc to the file whose PAB is at address n (constant or variable). Return the error code in Z.

**Input:**              Data Address, Name, Record Number (is the number of bytes to save)

**Output:**            The Data Bloc is copied to the file.

Note: *no previous FOPEN operation is needed.*

---

|    |                       |               |          |
|----|-----------------------|---------------|----------|
| Y7 | <b><i>FDELETE</i></b> | delete a file | <b>Z</b> |
|----|-----------------------|---------------|----------|

---

Syntax:      Y7n                  or                  ***FDELETE n***

Read the whole file whose PAB is at address n (constant or variable). Return the error code in Z.

**Input:**              Name

**Output:**            The file is closed and deleted.

---

|    |                        |                 |          |
|----|------------------------|-----------------|----------|
| Y8 | <b><i>FSCRATCH</i></b> | delete a record | <b>Z</b> |
|----|------------------------|-----------------|----------|

---

Syntax: Y8n or ***FWRITE n***

Delete a record from the file whose PAB is at address n (constant or variable). Return the error code in Z.

**Input:** Flag, Record length, Name, Record Number

**Output:** The record pointed by Record Number is deleted from the file.

---

|    |                       |                                   |          |
|----|-----------------------|-----------------------------------|----------|
| Y9 | <b><i>FSTATUS</i></b> | returns informations about a file | <b>Z</b> |
|----|-----------------------|-----------------------------------|----------|

---

Syntax: Y9n or ***FSTATUS n***

Returns the status byte information.

**Input:** Name

**Output:** Screen Offset contains a bit field as described below:

STATUS BYTE    a b c d e f g h

Bit a = 1 if file does not exist

Bit b = 1 if file is protected

Bit c = 0 unused

Bits de = 10 data internal, 00 data display, 01 program

Bit f = 1 variable length, else fixed length

Bit g = 1 physical device end reached

Bit h = 1 EOF

## **F18A support**

The TMS9918 of the TI-99/4A can be replaced with a new F18A with extra features. For example:

- using a **4 color BML (BitMap layer)**
- using the **second processor**, called the GPU, that can work directly on the VDP RAM with high performances (See ***\$GPU section*** for more informations.).
- using the **timer** (a clock in the TI!)
- extended mode with **40/80 columns**.

---

|                          |                                    |
|--------------------------|------------------------------------|
| <b><i>XREGENABLE</i></b> | enable use of extra F18A registers |
|--------------------------|------------------------------------|

---

Syntax: ***XREGENABLE***

This is a pseudo code equivalent to VDPREG 57 28 twice (or QV57.28). This is the sequence that tells the F18A to give access to the extended registers.



## ***BML : enhanced graphics with the BitMap Layer***

The **BML (BitMap layer)** is a kind of super sprite with definable position and size. It has four colors, so each byte contains 4 pixels of 2 bits each.

To define a BML, you must create a byte table with 6 bytes as this:

BYTE 0 : flags 8 bits as this eptxcccc  
Bit e : enable BML if 1  
Bit p : priority over tiles if 1  
Bit t : transparency (color 0 transparent) if 1  
Bit x : unused  
Bits cccc : palette number from 0 to 15.  
BYTE 1 : BML address in VDP RAM, this byte times 64.  
BYTE 2 : X position of the BML from 0 to 255  
BYTE 3 : Y position from 0 to 191  
BYTE 4 : W width up to 256  
BYTE 5 : H height up to 192

When transparency is set, color 0 is transparent and only colors 1 to 3 are seen.

Example:

```
STARTDATA
    Byte &b11100011      ; enable, prior, trans + palette #3
    Byte &h40           ; VDP address &h40 times 64 = &h1000 = 4096.
    Bytes 10,10,32,32   ; position 10,10 and size 32,32
ENDDATA E
```

So you can modify individual bytes using GETTABLE or PUTTABLE with E (i) .

---

|    |                      |                              |
|----|----------------------|------------------------------|
| QB | <b><i>BMLSET</i></b> | set bitmap layer information |
|----|----------------------|------------------------------|

---

Syntax: QBma or ***BMLSET m a***

Set the current BML definition block (for use with PLOT, DRAWTO and FILLRECT) and if m<>0 then send the inner information to the F18A hardware.

Example: (with previous definitions)

```
BMLSET 1 E          ; define my BML and make it appear (m=1)
PUTTABLE E(2) 50    ; change X to 50
BMLSET 1 E          ; apply new changes in the hardware.
```

---

QP    ***BMLPLOT***            plot a pixel in the BML

---

Syntax:            QPxyc            or            ***BMLPLOT x y c***

Plots pixel (x,y) in color "c".

The x position runs from 0 to W-1, y from 0 to H-1, upper left corner is (0,0).

The color c goes from 0 to 3.

Note: **no check for limits is performed**, so take care! You could delete data in VDP RAM outside your BML zone.

---

QD    ***BMLDRAWTO***            draw a line in the BML

---

Syntax:            QDxyc            or            ***BMLDRAWTO x y c***

Draws a line from the last plotted pixel to (x,y) in color "c". Several DRAWTO can be chained.

Example:

BMLPLOT 0 0 2            ; first pixel

BMLDRAWTO 30 30 2       ; draw from (0,0) to (30,30) in color 2

BMLDRAWTO 0 30 1        ; draw from (30,30) to (0,30) in color 1.

Note: **no check for limits is performed**, so take care! You could delete data in VDP RAM outside your BML zone.

---

QF    ***BMLFILLRECT***            fill rectangle in the BML

---

Stntax:            QFwh            or            ***BMLFILLRECT w h***

Fills a rectangle with dimensions (w,h) taking the last plotted pixel as the upper left corner. Limitations are these:

- The color is the same as the last plotted pixel
- The width must be multiple of 4
- The X position (of upper left corner) must be a multiple of 4.

Example: (with previous definitions), this clears the BML at start

BMLSET 0 E                ; just define my BML

BMLPLOT 0 0 0             ; upper left pixel in color 0

BMLFILLRECT 32 32        ; fills the whole BML with 0, so clear it!

BMLSET 1 E                ; now sends info to the F18A, the BML appears

Note: **no check for limits is performed**, so take care! You could delete data in VDP RAM outside your BML zone.

## ***TIMER : programming the 32bits counter***

The **F18A** has a **internal 32bits counter** that can be used as a clock (with a precision of 10ns) or as an event counter. Four bits are used to control it in the F18A through the extended register 37.

*With 32bits and 10ns the limit is:  $(2^{32}-1)*10^{-8} = 42,95$  seconds.*

**MLC** brings a second **6 bytes memory space** where you can load the counter value or cumulate it to bypass the 32bits limit. The internal counter and the MLC zone are independent, so you can clear one without affecting the other.

*With 47bits and 10ns, the limit is:  $(2^{47}-1)*10^{-8} = 390$  h 56' 14".*

|    |              |                            |                              |
|----|--------------|----------------------------|------------------------------|
| QT | <b>TIMER</b> | manages the 32bits counter |                              |
|    | Syntax:      | QTm                        | or <b>TIMER ..options...</b> |

"m" is a bit mask equal to the sum of each option's value:

| PreCompiler | MLC   | In R37 | Action taken                                     |
|-------------|-------|--------|--|
| CLEAR       | 32768 |        | Clear MLC counter                                |
| READ        | 16384 |        | Read F18A counter into MLC counter               |
| SUM         | 8192  |        | Read F18A and sum into MLC counter               |
| TOFLOAT     | 4096  |        | Convert MLC counter to float in r0               |
| (*)         | 2048  |        | If set, does not modify R37                      |
| RESET       | 8     | Yes    | Clear F18A counter                               |
| LOAD        | 4     | Yes    | Load F18A counter with values from xreg 38 to 41 |
| RUN         | 2     | Yes    | Run F18A counter as a 10ns clock                 |
| INC         | 1     | Yes    | Increment by one F18A counter                    |
| STOP        | 0     | Yes    | If it was running, then stop F18A clock          |

(\*) on the PreCompiler, if none of the R37 options is specified, then this bit is set automatically, so you don't have to care about it.

Example: you just want to know the duration of a portion of code that should last less than 43 seconds.

### ➤ **With the PreCompiler**

```
TIMER RESET RUN           ; timer set to zero and run
...your code here...
TIMER READ STOP TOFLOAT  ; get timer value and turns it into a float
.. and for example..
PUTFLOAT n i              ; to send back the float value to BASIC
```

➤ **The same with MLC**

```
QT10          ; 10 = 8 + 2 (RESET + RUN)
... your code here ...
QT20480       ; 20480 = 16384 + 4096 + 0 (READ + TOFLOAT + STOP)
'ZA
or
'Pni
```

Example: you want to know the duration of a portion of code that can be repeated and that can last more than 43 seconds.

➤ **With the PreCompiler**

```
TIMER CLEAR          ; init: clear MLC zone for sum
...
TIMER RESET RUN      ; start timer
...your code here...
TIMER SUM            ; sum into MLC zone
...
TIMER TOFLOAT        ; total into float register r0
```

➤ **The same with MLC**

```
QT32768          ; 32768 = CLEAR
...
QT10             ; 10 = 8 + 2 = RESET + RUN
... your code here ...
QT8192           ; 8192 = SUM
...
QT6144           ; 6144 = 4096 + 2048 = TOFLOAT + nothing in R37
```

Priority: the different actions are performed in the order of the table, so CLEAR is the first and STOP the last.

For example, if you use TIMER CLEAR TOFLOAT you will always get zero as CLEAR is performed before.

If you want to get the current value and then clear, you must provide two instructions:

```
TIMER TOFLOAT
TIMER CLEAR.
```



## ***TEXT : 40 or 80 columns, more lines and colors!***

The TI-99 has the ability to display 40 columns, but, as the **F18A** brings new features (80 columns, 30 lines, color in TEXT modes), this is discussed here.

---

**&W**            **TEXT32 TEXT40 TEXT80**            set text mode

---

Syntax:        &Wm            or        **TEXTnn [ options L30 XC ]**

Set the number of text rows and columns according to m:

| <b>TEXT mode</b> | <b>F18A</b> | <b>MLC</b> | <b>PreCompiler</b> | <b>Screen adr/size</b> | <b>Color table adr/size</b> |
|------------------|-------------|------------|--------------------|------------------------|-----------------------------|
| 30x24            |             | &W0        | TEXT32             | >00, 768 bytes         | >800 , 32 bytes             |
| 40x24            |             | &W1        | TEXT40             | >1000, 960 bytes       | >800 , unused (32B)         |
| 80x24            | *           | &W2        | TEXT80             | >1000, 1920 bytes      | >800 , unused (32B)         |
| 32x30            | *           | &W7        | TEXT32 L30         | >1000, 960 bytes       | >800 , 32 bytes             |
| 40x30            | *           | &W5        | TEXT40 L30         | >1000, 1200 bytes      | >800 , unused (32B)         |
| 80x30            | *           | &W6        | TEXT80 L30         | >1000, 2400 bytes      | >800 , unused (32B)         |
| 30x24 ext colors | *           | &W8        | TEXT32 XC          | >00, 768 bytes         | >1000, 256 bytes            |
| 40x24 ext colors | *           | &W9        | TEXT40 XC          | >1000, 960 bytes       | >00, 256 bytes              |
| 80x24 ext colors | *           | &W10       | TEXT80 XC          | >1000, 1920 bytes      | >00, 256 bytes              |
| 32x30 ext colors | *           | &W15       | TEXT32 L30 XC      | >1000, 960 bytes       | >00, 256 bytes              |
| 40x30 ext colors | *           | &W13       | TEXT40 L30 XC      | >1000, 1200 bytes      | >00, 256 bytes              |
| 80x30 ext colors | *           | &W14       | TEXT80 L30 XC      | >1000, 2400 bytes      | >00, 256 bytes              |

Unused color table: in those modes, only two colors are available: foreground and background. They are set with SCREEN (&S).

Extended colors: in those modes each character has its own attribute that you can set with ATTRIB (&A).

Note: in all modes, except &W0, you can't use the BASIC instructions PRINT, DISPLAY, CLEAR etc as they expect 32 columns, 24 lines and a screen image table at >0000.

Note: in all modes, except &W0, use of the **extended character zone** is limited as the address >1000 is common for characters and either the color table or the screen image. But, as the screen image table is moved, more characters in the standard zone are now available!

See **XPATTERN** (&X) for more information on this zone.

| TEXT mode        | Free chars in standard zone | Free chars in extended zone |
|------------------|-----------------------------|-----------------------------|
| 30x24            | 112: 32 to 143              | 256: 0 to 255               |
| 40x24            | 208: 32 to 143 & 160 to 255 | 132: 120 to 255             |
| 80x24            | 208: 32 to 143 & 160 to 255 | 16: 240 to 255              |
| 32x30            | 208: 32 to 143 & 160 to 255 | 132: 120 to 255             |
| 40x30            | 208: 32 to 143 & 160 to 255 | 106: 150 to 255             |
| 80x30            | 208: 32 to 143 & 160 to 255 | none                        |
| 30x24 ext colors | 112: 32 to 143              | 224: 32 to 255              |
| 40x24 ext colors | 176: 32 to 143 & 192 to 255 | 132: 120 to 255             |
| 80x24 ext colors | 176: 32 to 143 & 192 to 255 | 16: 240 to 255              |
| 32x30 ext colors | 176: 32 to 143 & 192 to 255 | 132: 120 to 255             |
| 40x30 ext colors | 176: 32 to 143 & 192 to 255 | 106: 150 to 255             |
| 80x30 ext colors | 176: 32 to 143 & 192 to 255 | none                        |

---

**&A**            **ATTRIB**            set character attribute

---

Syntax:        &Aca            or        **ATTRIB c a**

In extended color mode, set the individual attribute for a character.  
 "c" is the character (0-255) and "a" the attribute, 8 bits as this: PXYTCCCC

bit P: if 1, this character has priority over sprites.  
 bit X: flip horizontally the pattern  
 bit Y: flip vertically the pattern.  
 bit T: transparency instead of foreground color  
 CCCC : color selection.

For each pixel of the pattern, its bit is added to the right of CCCC to determine the actual color used:

Example, if CCCC = 1110

- a pixel ON will have color 11101 = 29
- a pixel OFF will have color 11100 = 28.

---

**Note on L30 flag (Line 30) and Sprites list.**

---

Extended Basic uses a marker for the end of sprite list (in dummy sprite #29) with a row value of 210 outside the display. With L30 flag ON, this value is now 250 as there are more rows of pixels!

If an unexpected sprite appears with L30, just add: **SLOCATE 29 250 1** (#L29.250.1)

When back to 24 lines, use: **SLOCATE 29 210 1** (#L29.210.1).

## ***Multicolor mode: 64x48 or 64x60 pixels in 16 colors***

The TI99 has the ability to display 64x48 blocs with 16 independent colors. With the F18A installed, you can increase this up to 64x60.

---

|               |                          |                      |
|---------------|--------------------------|----------------------|
| <b>&amp;W</b> | <b><i>MULTICOLOR</i></b> | set multicolour mode |
|---------------|--------------------------|----------------------|

---

Syntax:        **&Wm**        or        ***MULTICOLOR [ option L30 ]***

Set the display in multicolor mode according to m:

| <b>Display</b> | <b>F18A</b> | <b>MLC</b> | <b>PreCompiler</b> | <b>Screen adr/size</b> | <b>Pattern adr/size (*)</b> |
|----------------|-------------|------------|--------------------|------------------------|-----------------------------|
| 64 x 48        |             | &W16388    | MULTICOLOR         | >0000, 768             | >1000, 1536                 |
| 64 x 60        | *           | &W24576    | MULTICOLOR L30     | >1800, 1024            | >1000, 1920                 |

**Important note:** the pattern table must be moved to >1000, this is done with XPATTERN 2 instruction (&X2).

- So the complete sequence for Multicolor is:

|                   |                               |
|-------------------|-------------------------------|
| <i>With MLC :</i> | <i>With the PreCompiler :</i> |
| &X2               | XPATTERN 2                    |
| &W16388           | MULTICOLOR                    |

- And to go back to standard display, you must use:

|                   |                               |
|-------------------|-------------------------------|
| <i>With MLC :</i> | <i>With the PreCompiler :</i> |
| &X0               | XPATTERN 0                    |
| &W0               | TEXT32                        |

If you use the **L30** option, **XREGENABLE** must be provided first and read the previous note about the Sprite list termination.

In these modes, each pixel can be access with x coordinate from 0 (left) to 63 (right) and y coordinate from 0 (up) to 47 or 59 (down).

The colors are from 0 to 15 (not 1-16 like in the Extended Basic).

---

|               |                      |                                 |
|---------------|----------------------|---------------------------------|
| <b>&amp;p</b> | <b><i>MCPLOT</i></b> | plot a pixel in multicolor mode |
|---------------|----------------------|---------------------------------|

---

Syntax:        **&pxyc**        or        ***MCPLOT x y c***

Plot one pixel at position (x,y) with color c.

---

|               |                        |                                |
|---------------|------------------------|--------------------------------|
| <b>&amp;l</b> | <b><i>MCDRAWTO</i></b> | draw a line in multicolor mode |
|---------------|------------------------|--------------------------------|

---

Syntax:        **&lxyz**        or        ***MCDRAWTO x y c***

Draw a line from last plotted pixel to (x,y) in color c. Last pixel is the one from the last MCPLOT or MCDRAWTO instruction. So lines can be chained easily for a curve for example, or a box.

## **Debugging**

One main routine can help you debugging your code. It allows you to display the content of one to 6 variables or array elements. The values are given in hexadecimal.

### **1 With MLC**

The value displayed is always the content of the pseudo variable "[ ". So you have to fill it before either with:

=[v            for the content of variable v  
TGti[         for the content of the array element t(i).

Another pseudo variable, ], lets you specify which screen line will be used by the debugger giving the VDP starting address of the line:

C]            ]=0 for line 1  
=]32         ]=32 for line 2  
=]64         ]=64 for line 3

And so on, the address is 32 x ( Line -1 ).

By default, the address is zero.

Then using the code M, this runs the debugger routine.

The debugger routine requires the use of a 164 bytes buffer to save the content of the screen and of the characters it will redefine. So your program is preserved and will continue without any modification.

To specify the buffer address, you must use the third pseudo variable "\ " in a TR statement:

TR\164       reserve 164 bytes for the debugging session.

If you do not provide this buffer, the "M" routine will remain without effect.

---

M                            display content of the pseudo variable

---

Syntax: Mn

#### What the routine can do:

- Save the STATUS word to keep the conditional flags for jumps
- Save the debugger screen line
- Save the current definition of characters 96 to 111 (\*)
- Display the content of the pseudo variable "[" in hexadecimal in position 0 to 5.
- Output a tone (as Input does)
- Wait for a key
- Restore the debugger line
- Restore the char definitions
- Restore the STATUS word

So this instruction shouldn't interfere with the current program.

(\*) Note: the characters are mapped to 192 – 207 by the Extended Basic. If you used &X2 or &X3 to move the character table, then they are characters 192 to 207 equally. Those characters are temporarily redefined to display the 16 hexadecimal digits from 0 to F.

The "n" parameter allows you to select precisely the behaviour of the function. It is the sum of a series of flags that enable one operation each:

| PreCompiler | MLC    | Action taken   |
|-------------|--------|--|
| #SL         | 256    | Save the debugger line under hex values              |
| #SD         | 512    | Save char 192-207 definitions                        |
| #RC         | 1024   | Redefine chars 192-207 as the 0-F hexadecimal digits |
| #OB         | 2048   | Output a tone  |
| #WK         | 4096   | Wait for a key stroke and let your read values       |
| #RD         | 8192   | Restore char 192-207 definitions                     |
| #RL         | 16384  | Restore saved line                                   |
| #ALL        | 35512  | All actions performed                                |
| Position    | 0 to 5 | You can debug from 1 to 6 values on the same line    |

### Example of a debugging session:

```
TR\164           ; reserve zone

=[D              ; take value of variable D
&M35512         ; debug D with default values in position 0.
```

### Example of multi-debugging session:

```
TR\164           ; reserve zone

=[A
&M1792          ; debug A in position 0, save line and defs, define chars
                ; ( position 0 +256 + 512 + 1024 = 1792 )

=[B
&M1             ; debug B in position 1, every other operation disabled
                ; ( position 1 + 0 = 1)

=[C
&M30722        ; debug C in position 2, beep and wait key, then restore line and
                ; previous char defs.
                ; ( position 2 + 2048 + 4096 + 8192 + 16384 = 30722 )
```

In this session, you'll see variable A, B and C displayed in hexadecimal and then the computer waits for a key. For the first variable, the definitions of characters and the line are saved. For the last one, the definitions and the line are restored.

## 2 With the PreCompiler

To provide a buffer for the debugging routine, insert this pseudo-instruction:

```
DEBUG_BUFFER
```

If you want to use another line than the default first screen line, use:

```
DEBUG_LINE n ; n from 1 to 24
```

To display the content of a simple variable use:

```
DEBUG pos #ALL v ; pos from 0 to 5
```

To display the content of an array element, use:

```
DEBUG pos #ALL t(i)
```

Read carefully the section "1 With MLC" for details on the debugging routine. Only one `DEBUG_BUFFER` is necessary in the program, but it must precede the `DEBUG` call.

Note: Internally, the PreCompiler manages the pseudo variables `[ , ]` and `\`, so you don't have to deal with them.

If you want to select precisely the actions performed, you can use the options in the table on the previous page. If you turn an option `#XX` to `#-XX`, then you will disable it instead of enabling it (Example: `#ALL #-OB` means every action except output beep).

Example of a multi debugging session:

```
DEBUG_BUFFER ; reserve buffer
DEBUG 0 #SL #SC #RC A ; save defs, line, redefine chars and
; display A in position 0
DEBUG 1 B ; display B in position 1
DEBUG 2 #RL #RC #OB #WK C ; display C in position 2, output beep,
; wait key
; then restore line and char defs.
```

So you can watch variables continuously (disabling key stroke) or stop when you want to. If speed is important, then selecting exactly the actions you need allows you to let your program behave as normal.

## 4° The Precompiler unique features

Using the Precompiler gives you more flexibility and more power than the MLC alone. Pseudo-instructions have been added. They are not a synonym of a single MLC code, but they use a construction of several codes.

This simplifies your work and makes the source code clearer.

Another unique feature is the Inline Assembler to bypass the limitation of MLC. Let's start with...

### **The Pseudo-Instructions**

Unlike the SELECT/CASE structure integrated to MLC, the following can be nested. Internally, those constructions use labels. So, you **MUST** leave the upper case labels free (from Label A to Label Z) and you can use, for example, lower case or numeric labels.

---

#### ***NDO ... NLOOP***

---

Syntax:  
***NDO v n***  
    ..*instructions*..  
***NLOOP***

Initializes variable V with value n and execute the block of instructions for V equals n to 1. A total of n iterations.

Ex:

```
NDO J 7
    PUTCHAR (1, J) $*
NLOOP
```

This loop writes on the screen seven "\*" on the first line.

---

#### ***N0DO ... N0LOOP***

---

Syntax:  
***N0DO v n***  
    ..*instructions*..  
***N0LOOP***

Initializes variable V with value n and execute the block of instructions for V equals n to zero. A total of n+1 iterations.

Ex:

```
DIMTABLE A 10      ; reserve 10 words for array A
CLEAR B           ; B = 0
N0DO J 9
    PUTTABLE A(J) B
N0LOOP
```

This loop fills all elements A(9) to A(0) with the value of B, i.e. zero.

---

## ***N-1DO ... N-1LOOP***

---

Syntax:

***N-1DO v n***

..instructions..

***N-1LOOP***

Initializes variable V with value n-1 and execute the block of instructions for V equals n-1 to zero. A total of n iterations.

Ex:

```
DIMTABLE A 10          ; reserve 10 words for array A
CLEAR B                ; B = 0
N-1DO J 10             ; loop from 9 to 0
    PUTTABLE A(J) B    ; clear table
N-1LOOP
```

This loop fills all elements A(9) to A(0) with the value of B, i.e. zero.

---

## ***FOR ... NEXT***

---

Syntax:

***FOR v n m***

..instructions..

***NEXT***

Initializes variable V with value n and execute the block of instructions for V equals n to m. A total of (m-n+1) iterations.

Note: you must have  $m \geq n$ .

Ex:

```
FOR R 1 24              ; row from 1 to 24
    FOR C 1 32          ; column from 1 to 32
        PUTCHAR (R,C) $Z ; write "Z"
    NEXT
NEXT
```

This loop fills the whole screen with character "Z".

---

## ***REPEAT ... UNTILtest***

---

Syntax:

***REPEAT***

..instructions..

***UNTILtest***

The bloc of instructions is executed until the test is positive. The six tests are allowed:  
***UNTIL=, UNTIL<>, UNTIL>, UNTIL<, UNTIL>=, UNTIL<=.***



Ex:

```
SAY &wHELLO           ; say one word
REPEAT
    TALKING?           ; talking is finished?
UNTIL<>                 ; if =, no, so wait
SAY &wYOU              ; if <>, say next word
```

The word HELLO is said, then the loop waits until the computer is not talking anymore, then it says YOU.

---

### ***DO ... WHILEtest ... LOOP***

---

Syntax:

```
DO
    ..instructions 1..
WHILEtest
    ..instructions 2 ..
LOOP
```

Will execute the two blocs of instructions between DO and LOOP while the test is positive. Note that "instructions 1" is always executed at least once.

The six tests are allowed:

**WHILE=**, **WHILE <>**, **WHILE >**, **WHILE <**, **WHILE >=**, **WHILE <=**.

Ex:

```
LET A &hA000           ; start of high memory
LET J 0                 ; index in A
DO
    GETTABLE A(J) B     ; read one word from memory
WHILE=
    INC J               ; next index
LOOP                    ; exit loop if word <>0 found
```

---

### ***IFtest ... ENDIF***

---

Syntax:

```
IFtest
    ..instructions ..
ENDIF
```

Execute the bloc of instructions only if the test is positive.

The six tests are allowed:

**IF=**, **IF <>**, **IF >**, **IF <**, **IF >=**, **IF <=**.

Ex:

```
LABEL x
    SLOCATE 1 (R,C)      ; locate sprite
    INC C                ; next column
    COMPARE C 256       ; limit is 256
    IF>
        LET C 1         ; if limit reached, return to 1
    ENDIF
GOTO x                  ; again
```

---

### ***IFtest ... ELSE ... ENDIF***

---

Syntax:

***IFtest***

.. instructions 1 ..

***ELSE***

.. instructions 2 ..

***ENDIF***

Execute the bloc of "instructions 1" if the test is positive and "instructions 2" if the test is negative.

The six tests are allowed:

***IF=, IF <>, IF >, IF <, IF >=, IF <=.***

Ex:

```
KEYWAIT 0                ; suppose we wait for ENTER
COMPARE K 13             ; is it ENTER (code 13)
IF=
    SAY &wTHAT_IS_RIGHT ; if so, congratulations
ELSE
    SAY &wTHAT_IS_INCORRECT ; else, too bad.
ENDIF
```

---

### ***BYTES WORDS***

#### ***STARTDATA ... ENDDATA v***

---

Pseudo-instructions explained in section "**Arrays**" and particularly in :

**"Note on data initialization" / "b- With the PreCompiler".**

Note: BYTES and WORDS use internally the **HEX** (TH) code

---

### ***FLAGS***

---

Syntax: ***FLAGS*** ...key words...

The keywords are: ***INTERNAL, DISPLAY, SEQUENTIAL, RELATIVE, INPUT, OUTPUT, APPEND, UPDATE, FIXED, VARIABLE.***

The instruction is equivalent to **BYTE** and builds the value according to the key words. Use it into the PAB structure. See **File Access**.

## **The Inline Assembler**

Let's enter a deeper world: the assembler! If you work with MLC and the PreCompiler, you'll surely find some limitations in what can be done. Sometimes in terms of speed or sometimes in terms of ability.

Why those limits? The main answer is that MLC uses the low ram expansion that is limited to 8KB and I couldn't integrate everything in it. The other answer is that I can't predict everything that programmers can imagine!

### **MLC and Assembler dialog**

The Assembler and MLC can exchange data through the 26 variables from A to Z. They are predefined in the assembler, so you can write:

```
MOV @A,R9
```

This copies the value of variable A into register R9.

```
LI R0,K ; r0 points to the K variable
CLR *R0+ ; clear K
CLR *R0+ ; clear L
CLR *R0 ; clear M
```

You can access the two standard Floating Point registers that I named r0 and r1 in MLC. They correspond to FAC and ARG in Assembler.

```
LI R0,FAC ; points to r0=FAC
LI R1,ARG ; points to r1=ARG
LI R2,4 ; four words to treat
MOV *R0,R3 ; exchange FAC and ARG
MOV *R1,*R0+
MOV R3,*R1+
DEC R2 ; decrement counter
JNE -5 ; if not ended, jump back 5 words (jne included)
```

---

```
$( ... $) enter and exit assembler
```

---

Those instructions must appear on a single line, as every PreCompiler instruction, so you can't write :

```
$( INCT @D $)
```

But instead, you must use this:

```
$(
    INCT @D
$)
```

---

**DATA      BYTE      EVEN**

---

DATA is the assembler equivalent for **WORDS** in the PreCompiler:

Syntax:      DATA w1, w2, w3, . . . .

BYTE is the assembler equivalent for **BYTES** in the PreCompiler:

Syntax:      BYTE b1, b2, b3, . . .

EVEN is equivalent to EVEN in the PreCompiler and is used to ensure that the compilation pointer is even.

Syntax:      EVEN

---

**LABEL      GOTO**

---

They are equivalent to LABEL and GOTO in the PreCompiler. They share the same label space, so take care not to duplicate a label!

You can GOTO from the Assembler to a label outside.

You can GOTO from outside to a label in the Assembler bloc.

**Note:** you can't use a Label with the B, BL, or BLWP instructions, GOTO is the only way (and is equivalent to B).

**Note:** you can't use a label with the JMP and conditional jumps instructions. For those, you must calculate yourself the offset in words. See "**The JMP problem**".

### **Note on the addressing modes**

Six addressing modes are available:

|           |              |  |
|-----------|--------------|--|
| Rn        | register     | refer to a workspace register $0 \leq n \leq 15$ |
| *Rn       | indirect     | refer to the value pointed by a register         |
| @address  | address      | refer to the value pointed by the address        |
| @adr (Rn) | adr indexed  | refer to the value pointed by address + Rn       |
| *Rn+      | ind auto inc | same as *Rn but then Rn incremented              |
| constant  | immediate    | the value itself                                 |

the addresses or constants can be:

- A decimal value from -32768 to 32767, or 0 to 65535 for words
- A decimal value from -128 to 127 or 0 to 255 for bytes
- An hexadecimal value with ">" prefix such as >8300
- A variable from A to Z
- One of the standard references of the Assembler listed here:

GPLLNK, FAC, ARG, VDPWA, VDPWD, VDPRD, VDPSTA, GPLWS, PAD  
SOUND, SPCHRD, SPCHWT, GRMRD, GRMRD, GRMWD, GRMWA

SCAN, NUMASG, NUMREF, STRASG, STRREF, XMLLNK, KSCAN  
 VSBW, VMBW, VSBR, VMBR, VWTR, ERR, FADD, FSUB  
 FMUL, FDIV, SADD, SSUB, SMUL, SDIV, CSN, CFI  
 FCOMP, NEXT, COMPCT, GETSTR, MEMCHK, CNS, VPUSH  
 VPOP, ASSGNV, CIF, SCROLL, VGWITE, G VWITE, DSRLNK

### Addressing mode usage

The arguments passed to an assembly instruction can be of three types:

- I. REG: A register with the only addressing mode Rn
- II. CST: A constant
- III. GEN: A general argument that can be Rn, \*Rn, @address, @adr(Rn) or \*Rn+

### Instructions OPCODE Gen,Gen

Those instructions require two GENERAL arguments. The first is the source and the second the destination where the result will be stored.

|      |                  |      |                               |      |                              |
|------|------------------|------|-------------------------------|------|------------------------------|
| A    | <i>Add</i>       | AB   | <i>Add bytes</i>              | S    | <i>Sub</i>                   |
| SB   | <i>Sub bytes</i> | C    | <i>Compare</i>                | CB   | <i>Compare bytes</i>         |
| MOV  | <i>Move</i>      | MOVB | <i>Move byte</i>              | SOC  | <i>Set one corresponding</i> |
| SOCB | <i>Soc byte</i>  | SZC  | <i>Set zero corresponding</i> | SZCB | <i>Szc byte</i>              |

Ex: MOV @>2004, R2    move in R2 the content of word at address >2004.

### Instructions OPCODE Gen,Reg

Those instructions take the source in a GENERAL argument and the destination is a REGISTER.

|     |                                   |     |                                    |     |                     |
|-----|-----------------------------------|-----|------------------------------------|-----|---------------------|
| COC | <i>Compare ones corresponding</i> | CZC | <i>Compare zeros corresponding</i> | XOR | <i>Exclusive or</i> |
| MPY | <i>Multiply</i>                   | DIV | <i>Divide</i>                      |     |                     |

Ex: XOR \*R4+, R5    take word pointed to by R4, performs an exclusive OR in R5 and then increment R4 by two (words are concerned).

### Instructions OPCODE Reg,Cst    or OPCODE Reg,R0

Those instructions move the bits of a word located in a REGISTER. The shift count is either a non zero CONSTANT or the content of REGISTER 0.

|     |                              |     |                               |
|-----|------------------------------|-----|-------------------------------|
| SLA | <i>Shift left arithmetic</i> | SRA | <i>Shift right arithmetic</i> |
| SRL | <i>Shift right logical</i>   | SRC | <i>Shift right circular</i>   |

Ex: SRA R5, 7    shift R5 seven positions to the right keeping its sign.

---

**Instructions OPCODE Reg,Cst**

---

Those instruction use a ConSTant as first argument to perform an operation into a REGISTER.

|    |                          |      |                      |    |                       |
|----|--------------------------|------|----------------------|----|-----------------------|
| AI | <i>Add immediate</i>     | ANDI | <i>And immediate</i> | LI | <i>Load immediate</i> |
| CI | <i>Compare immediate</i> | ORI  | <i>Or immediate</i>  |    |                       |

Ex: LI R1, FAC load into R1 the address of FAC  
LI R2, D load into R2 the address of variable D

---

**Instructions OPCODE Reg**

---

Those instructions store a value into a REGISTER.

|      |                     |      |                                |
|------|---------------------|------|--------------------------------|
| STST | <i>Store status</i> | STWP | <i>Store workspace pointer</i> |
|------|---------------------|------|--------------------------------|

Ex: STST R6 store status register in R6

---

**Instructions OPCODE Gen**

---

Those instructions operate on one GENeral argument to get the value or/and store the result.

|      |                       |     |                        |      |                                     |
|------|-----------------------|-----|------------------------|------|-------------------------------------|
| ABS  | <i>Absolute</i>       | CLR | <i>Clear</i>           | DEC  | <i>Decrement</i>                    |
| DECT | <i>Decrement by 2</i> | INC | <i>Increment</i>       | INCT | <i>Increment by 2</i>               |
| INV  | <i>Inverse (not)</i>  | NEG | <i>Negate</i>          | SETO | <i>Set to one</i>                   |
| B    | <i>Branch</i>         | BL  | <i>Branch and link</i> | BLWP | <i>Branch and link workspace pt</i> |
| SWPB | <i>Swap bytes</i>     | X   | <i>execute</i>         | CALL | <i>Call subroutine F18A</i>         |
| PUSH | <i>Push F18A</i>      | POP | <i>Pop F18A</i>        | SLC  | <i>Shift left circular F18A</i>     |

Ex: SETO @>8300 fills word at address >8300 with >FFFF  
BLWP @VMBR jump into a system routine for VDP multi byte read

---

**Instructions OPCODE Cst**

---

Those instructions use a ConSTant to modify a CPU register.

|      |                                      |      |   |
|------|--------------------------------------|------|---|
| LIMI | <i>Load interrupt mask immediate</i> | LWPI | <i>Load workspace pointer immediate</i> |
|------|--------------------------------------|------|---|

Ex: LWPI >5000 will use 32 bytes starting at >5000 for R0 to R15.

---

**Instructions OPCODE**

---

No argument is required.

|      |                     |     |                         |      |                                 |
|------|---------------------|-----|-------------------------|------|---------------------------------|
| NOP  | <i>No-operation</i> | RT  | <i>Return (=B *R11)</i> | RTWP | <i>Return workspace pointer</i> |
| IDLE | <i>With F18A</i>    | RET | <i>Return sub F18A</i>  |      |                                 |

---

### ***Instructions OPCODE Gen,Cst***

---

Those instructions use a GENeral argument as source and a constant for destination.

|      |                     |      |                      |     |                           |
|------|---------------------|------|----------------------|-----|---------------------------|
| LDCR | <i>Load CRU bit</i> | STCR | <i>Store CRU bit</i> | XOP | <i>Extended operation</i> |
|------|---------------------|------|----------------------|-----|---------------------------|

Ex: LDCR \*R1,7 send seven bits from address pointed by R1 to the CRU, the CRU address is in R12.

---

### ***Instructions OPCODE Cte***

---

For the jump instructions the ConSTant is an offset in words, for the CRU instructions, the ConSTant is an offset in CRU memory added to the content of R12.

|     |                              |     |                             |     |                             |
|-----|------------------------------|-----|-----------------------------|-----|-----------------------------|
| JEQ | <i>Jump if equal</i>         | JGT | <i>Jump if greater than</i> | JH  | <i>Jump if high</i>         |
| JHE | <i>Jump if high or equal</i> | JL  | <i>Jump if low</i>          | JLE | <i>Jump if low or equal</i> |
| JLT | <i>Jump if less than</i>     | JMP | <i>Jump</i>                 | JNC | <i>Jump if no carry</i>     |
| JNE | <i>Jump if not equal</i>     | JNO | <i>Jump if no overflow</i>  | JOC | <i>Jump on carry</i>        |
| JOP | <i>Jump if odd parity</i>    |     |                             |     |                             |
| SBO | <i>Set cru bit to one</i>    | SBZ | <i>Set cru bit to zero</i>  | TB  | <i>Test bit</i>             |

### **The JMP problem**

The jump instruction includes a relative offset in words where to jump, this offset is integrated into the OPCODE word in the less significant byte.

MLC only manages labels and jumps with the B (branch) opcode that uses a second word with the absolute address. So, MLC can't manage those JUMPs !

You have to deal with word offsets yourself!

Ex: JMP +0        jump to the next instruction  
      JMP -1        jump to the jump itself, infinite loop.

Here...

```
MOV *R1+, *R2+
DEC R4
JNE -3        to jump back "here", 3 words for 3 instructions including JNE
```

Note: to jump backward, the jump instruction must be included in the word count, to jump forward, you don't have to include it.

Note: using @address or @addr(Rn) addressing modes adds one word in the instruction. If the two operands use this mode, then it adds two words to the instruction!

Here...

```
MOV @FAC, *R2+
DEC R4
JNE -4        to jump back "here", 4 words as the MOV + FAC use 2 words
```

JMP +2       to jump "there", two simple instructions  
NEG R3  
MOV R3, R5

There...

Jmp +3               to jump there  
Mov @A, @B       3 words in a single instruction!

There...

Note: *using instructions ending with "I" such as ANDI, LIMI require an extra word to store the immediate operand.*



## 5° Error codes:

- 0 No error
- 10 “:” expected because there are more “;” (return) than entry points.  
*There are more RETURN than SLABEL.*
- 11 return expected, there are more “:” entry points than returns  
*There are more SLABEL than RETURN.*
- 12 bad argument: a constant expected but variable found or vice-versa.
- 13 bad name, the name routine is not correct (null or more than 6 chars)
- 14 bad parameter: a variable or numeric value is expected
- 15 bad table name (must be from A to X in general and from A to H for TR reservation)
- 16 double definition, you try to define the same label twice
- 17 duration expected to end a block in SND section
- 18 F or V required before voice frequency or volume in SND section
- 19 missing starting “[“ when you use “%” or “[“].  
*CASE or ENDCASE without SELECT.*
- 20 nested structures, you start a second “[“ without closing the first one with “]”  
*A new SELECT found before you closed the previous with ENDSELECT.*
- 21 Out of Range, constant mode in “K”, “J” or Sound exceeds the known values  
*This can't appear with the PreCompiler.*
- 22 unknown instruction code
- 23 unexpected end of line: a macro code must fit into one single string and not be cut in two parts  
*This shouldn't appear with the PreCompiler.*
- 24 unexpected end of DATA lines (missing DATA "" ?)  
*You forgot the end of section \$\$ or the general end \$END marker.*
- 25 undefined label(s), you have jumped to a label that doesn't exist, or the “]” is missing to resolve every jump at the end of a “[“ structure.  
*You jump to a label that doesn't exist or a structure is not closed (missing ENDSELECT, ENDIF, LOOP, etc.)*
- 26 the line number in IO(1) passed to "COMPIL" doesn't exist.
- 27 unknown identifier: a section must start with P, S or C. Something else found.
- 28 sign expected after ? or ! in conditional jump (?=, ?>, ?<, !=, !<, !>)  
*This can't appear with the Precompiler.*
- 29 trying to kill an unresolved label

## 6° Examples

### PI Calculation, Floating point example

The program calculates PI with the sum  $1/n^2$  equals to  $PI^2/6$  with n infinite. The sum is computed both in MLC and in XB to show the difference.

Results: n=3000, MLC 28 seconds, XB 69 seconds.

```
100 CALL CLEAR
$MLC F 110 10 3000
1000 INPUT "N=":N
1005 INPUT "READY FOR MLC...":R$
1010 CALL LINK("PI",N,P)
1020 PRINT "PI=";P::PRINT
1030 INPUT "READY FOR XB...":R$
1040 S=1:: FOR I=N TO 2 STEP -1
1050 S=S+1/(I*I)::NEXT I
1060 P=SQR(6*S)::PRINT "PI=";P::PRINT
1070 GOTO 1000
$PI
    FARRAY 0
    FLOAT 1          ; send float 1 in r0
    FMOVE 0 3 ; save "1"
    FMOVE 0 2 ; sum initialized with "1"
    GETPARAM 1 N
    FLOAT N          ; r0=N
    DEC N
    NDO N N
        FMOVE 0 1 ; dup
        FMUL      ; N^2
        FMOVE 3 1 ; '1'
        FDIV      ; 1/N^2
        FMOVE 2 1 ; sum
        FADD      ; sum+1/N^2
        FMOVE 0 2 ; sum saved
        FLOAT N   ; new N
    NLOOP
    FLOAT 6          ; send float 6 in r0
    FMOVE 2 1 ; sum in r1
    FMUL
    FSQR          ; sqr(6*sum)=PI !!
    PUTFLOAT 2(0) ; returns PI
$$
$END
```

## Prime numbers, set management example

This program looks for all the prime numbers from 2 to 32767 with the Eratosthenes' method.

Only 22 seconds are necessary to answer that there are 3512 prime numbers.

```
100 CALL CLEAR
;
; compiler inserted
;
$MLC F 110 10 3000
;
; call to my routine
;
310 CALL LINK("ERATHO",C)
;
; upon return, C=number of primes
;
320 PRINT C;" prime numbers":PRINT "from 2 to 32767."
330 END
;
; the program
;
$ERATHO
    DIMSET 2 32767 A      ; A is a set with elements from 2 to 32767
    SETFILL A            ; all elements in A
    LET B 2              ; first element to find
    DO
        SETFINDNEXT A B  ; look for an element in A starting from B
    WHILE=               ; if found, then B=value, and B is PRIME
        LET C B          ; take the prime number
        DO
            ADD C B      ; computes 2*B, 3*B, 4*B, etc...
        WHILE>
            ELEMENT- A C ; and remove this list from A
        LOOP
        INC B            ; see if there is another prime number after B
    LOOP
    SETCARD A C         ; computes cardinal of set A
    PUTPARAM 1 C        ; and return the cardinal
$$
$END
```

## Roman numbers, string and table management.

This program returns the roman number form of an integer. It can return two different forms: the classic using standard rules and the compact one where you can save some signs (example VM = 1000 – 5 = 995 instead of CMXCV).

```

100 CALL CLEAR
$MLC F 110 10 3000
300 INPUT "A=":A
;
; last parameter 0 for COMPACT form
; or 1 for CLASSIC form with restrictive rules for subtraction
;
310 CALL LINK("ROMAN",A,COM$,0)::CALL LINK("ROMAN",A,CLA$,1)
;
; if compact and classic are equal, write one answer
;
320 IF COM$=CLA$ THEN PRINT " = ";COM$::GOTO 300
;
; else write the two forms
;
330 PRINT " COMPACT = ";COM$::PRINT " CLASSIC = ";CLA$::GOTO 300
$ROMAN
STARTDATA
WORDS 1000,-999,-995,-990,-950,900 ; create a word table with values of
WORDS 500,-499,-495,-490,-450,400 ; usable symbols or combined symbols (by pair)
WORDS 100,-99,-95,90 ; negative values for compact form only
WORDS 50,-49,-45,40
WORDS 10,9,5,4,1,0
ENDDATA A ; this table pointed by A (cause A, B, C, D are words table pointers)
STARTDATA
STRING "M IMVMXMLMCM" ; create a long string with symbols alone or by pair
STRING "D IDVDXDLDCD"
STRING "C ICVCXC"
STRING "L ILVLXL"
STRING "X IXV IVI "
ENDDATA E ; pointed by E (cause E, F, G, H are byte table pointers)
DIMTABLE F 255 ; the output string reserved here with 255 max chars
GETPARAM 1 X ; get the value to be converted in X
GETPARAM 3 T ; flag for classic/compact
CLEAR K ; will point into output string (0 to 254)
CLEAR I ; points into A() (from 0 to 25, the last A(25) is null for marker)
CLEAR J ; points into E() string (from 0 to 49)
DO
COMPARE T 0 ; compact form?
IF= ; YES
GETTABLE A(I) Y ; one value from table A() into Y
ABS Y ; and accept >0 or <0, no restriction
ELSE ; here classic form
DO
GETTABLE A(I) Y ; read a value
WHILE< ; if negative, rejected
INC I ; next
ADD J 2
LOOP
ENDIF
WHILE<>
DO
COMPARE X Y ; does Y fit in X?
WHILE>=
SUB X Y ; if YES, remove Y from X
GETTABLE E(J) C ; get one symbol
PUTTABLE F(K) C ; and put it into output string
INC J ; see next
INC K ; idem
GETTABLE E(J) C ; get next symbol
COMPARE C 32 ; is it a SPACE? (32)
IF<>
PUTTABLE F(K) C ; if not, it's a pair, add second symbol
INC K ; one more char
ENDIF
DEC J ; back on 1st symbol if to be repeated
LOOP

```



```

DIMTABLE E 256 ; enough for 8 lines
BMOVEVTOC 448 256 E ; load 8 lines (address 480) from screen to my buffer (E)
DIMTABLE F 8 ; to load one char definition
LET B E
INC B ; B = E+1 for one shift
LET G 1
COLOR 16 1 16
FOR I 1 32
    PUTCHAR 14 I 128
    PUTCHAR 24 I 128
    PUTCHAR 1 I 129
    PUTCHAR 12 I 129
NEXT
FOR I 2 11
    PUTCHAR I 1 129
    PUTCHAR I 32 129
NEXT
LET I 5
LET J 3
INTERRUPT
REPEAT
    GETTABLE C(I) X
    DEC I
    GETTABLE C(I) Y
    SMOTION J X Y
    DEC J
    DEC I
UNTIL<
DO
    GETTABLE U(R) M ; string address in M and len in Z compared to zero
WHILE<>
    DEC Z ; while len not null
    FOR I 0 Z
        GETTABLE M(I) S ; one character from string
        ADD S 96
        MUL S 8 ; s= VDP ram address of char definition
        BMOVEVTOC S 8 F ; take definition
        NDO N 8 ; 8 columns
        BMOVE B 255 E ; shift one position to the left
        LET P 31 ; fist position in table
        FOR J 0 7
            INTERRUPT
            GETTABLE F(J) A ; one def byte
            COMPARE A 128
            IF>=
                SUB A 128
                LET Q 138 ; "*"
            ELSE
                LET Q 128 ; " "
            ENDIF
            ADD A A ; shift A for next bit
            PUTTABLE F(J) A ; and stores it
            PUTTABLE E(P) Q ; correct char in table
            ADD P 32 ; next line
        NEXT
        NEG G
        IF<
            COLOR 16 1 16
        ELSE
            COLOR 16 16 1
        ENDIF
        DEFCHAR 2(N) 42
        BMOVECTOV E 256 448 ; copy to screen !!
        GOSUB c ; sprite managment
        NDO J W
        NLOOP ; wait loop
    NLOOP
NEXT
INC R ; next string
LOOP
SMAX 0 ; stop all sprites
GOTO x ; end

```

; this is the subroutine to verify the positions of the sprites and  
; make them bounce

SLABEL c

```

TALKING?
IF<>
    GETTABLE D(K) H          ; next word to say
    IF=
        CLEAR K
        GETTABLE D(K) H
    ENDIF
    INC K
    SAY H
ENDIF
LET L 5                      ; index into C() table
NDO H 3                      ; for 3 sprites
    LET Q 0                  ; default is no change
    GETTABLE C(L) T          ; current vertical motion
    SPOSITION H X Y          ; position of sprite H (3, 2 or 1)
    LIMIT 8 60 X            ; vertical position into limits?
    IF<>
        NEG T                ; if not, change vertical speed
        PUTTABLE C(L) T      ; and store new motion
        INC Q                ; mark a change
    ENDIF
    DEC L
    GETTABLE C(L) V          ; current horizontal motion
    LIMIT 8 216 Y           ; horizontal position into limits?
    IF<>
        NEG V                ; if not, change horizontal motion
        PUTTABLE C(L) V      ; stores it
        INC Q                ; mark a change
    ENDIF
    DEC L
    ABS Q                    ; just to test Q
    IF<>
        SLOCATE H X Y        ; if a change, new position
        SMOTION H T V        ; and new motion
    ENDIF
    INTERRUPT                ; to enable auto motion
NLOOP
RETURN
LABEL x
$$
$CHAR
    ; the 8 chars are the growing points that form letters in the scroll

0000001818000000 0000183C3C180000 003C7E7E7E7E3C00 7EFFFFFFFFFFFF7E
7EFFFFFFFFFFFF7E 003C7E7E7E7E3C00 0000183C3C180000 0000001818000000

    ; those two chars to surround the text and the bouncing MLC

S128.0F1E3C78F0783C1EE7E7E7FFFE7E7E7
$$
$END
; A = one def byte
; B = adress E+1 for scroll
; C = table for sprite motions
; D = table for speech sentence
; E = CPU RAM buffer for 8 lines (bytes)
; F = CPU RAM buffer for one char def (bytes)
; G = flag +/-1 to swap colors of char 128
; H =
; I = character loop from 0 to len(string)-1
; J = loop for 8 definitions bytes when creating one column
; K = pointer in speech table D
; L =
; M = VDP RAM address of string (bytes)
; N = loop for 8 columns per character
; O =
; P = pointer into E buffer for the 8 new characters when creating a column
; Q = char "*" or " " / flag in subroutine
; R = string index
; S = VDP RAM address of one char definition
; T =
; U = 1 to access the first parameter in CALL LINK as a string array
; V =
; W = wait loop
; X =
; Y =
; Z = len of string

```

# PONG game, sprites, graphics and sounds

This is the PONG game that you all (should) know.

```
100 CALL INIT::CALL CLEAR::DIM S$(3)
; load compiler and compiles game and sounds

110 GOSUB 1000

; ball, paddle, net and field definitions

140 CALL CHAR(96,"60F0F0F0F0F0F060")::CALL CHAR(100,"60F0F06000000000")
150 CALL CHAR(97,"8855225588552255")::CALL CHAR(98,"FFFFFFFFFFFFFF")::CALL
CHAR(99,"0000000000000000")

; prepares screen

160 CALL CLEAR::CALL SCREEN(1)::CALL COLOR(9,16,10)
170 FOR I=1 TO 8::CALL COLOR(I,4,1)::NEXT I
180 RESTORE 900::READ M$,N$,P$::READ SP(1),SP(2),SP(3),SP(4)
190 DISPLAY AT(1,13):"PONG"
200 DISPLAY AT(2,1):M$
210 FOR I=3 TO 19::DISPLAY AT(I,1):N$::NEXT I
220 DISPLAY AT(11,1):P$::DISPLAY AT(20,1):M$
230 DISPLAY AT(21,2):"LEFT (X-E)      RIGHT (I-M)"
240 SC(1)=0::SC(2)=0::START=1::SPEED=2::CALL MAGNIFY(2)

; display little menu and wait for SPACE to start

250 DISPLAY AT(24,1):"SPACE=START  S=SPEED  Q=QUIT"
260 DISPLAY AT(22,7):SC(1)::DISPLAY AT(22,21):SC(2)::GOSUB 400::IF K$<>" " THEN 250

; sprites 2 and 3 are the paddles, sprite 1 the ball

270 CALL SPRITE(#2,96,5,16,24)::CALL SPRITE(#3,96,14,136,224)
280 CALL SPRITE(#1,100,13,120*START-102,184*START-152)

; call assembly routine to play

290 CALL LINK("PLAY",S$(),START,SP(SPEED),WIN)

; upon return, WIN is the winner!

300 SC(WIN)=SC(WIN)+1:: START=3-START::GOTO 260

; quit game, the assembly routine is deleted from ram

310 CALL LINK("POP",A)::PRINT A
320 END

; menu key

400 CALL KEY(0,K,S)::K$=CHR$(ABS(K))::IF K$=" " THEN RETURN
410 IF K$="S" OR K$="s" THEN 420
415 IF K$="Q" OR K$="q" THEN 310 ELSE 400
420 DISPLAY AT(24,1):"SELECT SPEED FROM 1 TO 4:";SPEED
430 ACCEPT AT(24,27)SIZE(-1)BEEP:SPEED
440 RETURN

; field definition

900 DATA "bbbbbbbbbbbbbaabbbbbbbbbbbb"
910 DATA "bcccccbcccccaacccccbcccccb"
920 DATA "bcccccbbbbbbaabbbbbcccccb"

; speed table 1 to 4

930 DATA 10,20,35,50

; includes here the loader from line 1000 and DATA from line 2000
```



```
$MLC F 1000 10 2000
1900 RETURN
```

```
; sound definitions
```

```
$SND 1 ; ball touches paddle 1
      FA440VA0VN15D2 VA2D3 VA4D4 VA6D5 VA8D6,VA12D7 VA14D8 VA15D0
$$
$SND 2 ; ball touches paddle 2
      FA220VA0VN15D2 VA2D3 VA4D4 VA6D5 VA8D6,VA12D7 VA14D8 VA15D0
$$
$SND 3 ; ball touches border
      FN5VN8VA15D1 VN6D1 VN4D1 VN6D1 VN8D2,VN12D2 VN15D0
$$
```

```
; game routine
```

```
$PLAY
```

```
GETPARAM 2 S ; S=start player (1/2)
GETPARAM 3 H ; horizontal speed
RND ; random number in Z
DIV Z H ; remainder (so Z<H)
LET G Z ; vertical speed!
LET M 1 ; default player 1
COMPARE S 1
IF<> ; if start player is not 1
      NEG G ; modifies motion and M=2
      NEG H
      INC M
ENDIF
SMAX 1 ; one sprite with auto motion
SMOTION 1 G H ; ball starts !
SOUND M ; with a paddle sound
SPOSITION 2 A B ; get positions of both paddles
SPOSITION 3 C D
DO
      INTERRUPT ; enables interrupt for auto motion

; here player ONE

KEY 1 ; read keyboard left, key in K and COMPARE K 0 performed
IF>= ; a key pressed!
      IF= ; if equal 0, it is X
          INC A ; here "X"=down, A=A+1
      ELSE
          COMPARE K 5 ; is it "E"?
          IF=
              DEC A ; here "E"=up, A=A-1
          ENDIF
      ENDIF
LIMIT 16 136 A ; ensure A is in the range
SLOCATE 2 A B ; and set new paddle position
ENDIF

COMPARE K 18 ; is it "Q"
WHILE<> ; if so QUIT !

GOSUB b ; manages ball movement

; here player TWO

KEY 2 ; read keyboard right, key in K and COMPARE K 0 performed
IF>= ; a key pressed!
      IF= ; if 0, it is "M"
          INC C ; if "M"=down, C=C+1
      ELSE
          COMPARE K 5 ; is it "I"?
          IF=
              DEC C ; if "I"=up, C=C+1
          ENDIF
      ENDIF
LIMIT 16 136 C ; ensure C is in the range
SLOCATE 3 C D ; new position
ENDIF

GOSUB b ; manages ball movement
```

```

LOOP                                ; and back to paddle one !!!

GOTO x                               ; here if K=18, "Q" key, QUIT

; Subroutine for ball movement

SLABEL b
SPOSITION 1 E F                      ; get ball position
LIMIT 16 144 E                      ; is the vertical position in the field?
IF<>                                  ; no, so modifications!
    NEG G                            ; reverse motion
    SMOTION 1 G H                    ; reflexion
    SLOCATE 1 E F                   ; new location
    SOUND 3                          ; and border sound
ENDIF

LIMIT 24 224 F                      ; is the horizontal position in the field?
IF<>THEN x                            ; if not, game has ended!

LIMIT 32 216 F                      ; else, are we far from the paddles?
IF<>                                  ; not so far, verify contact
    IF<                               ; if under 32 then work with paddle 1
        LET G A                      ; take vertical position of...
        LET M 1                      ; ...paddle 1
    ELSE
        LET G C                      ; else take vertical position of...
        LET M 2                      ; ...paddle 2
    ENDIF
    SUB G E                          ; vertical distance G-E
    LIMIT -16 8 G                    ; is it in -16,8 ?
    IF=                               ; yes so, contact!
        ADD G 4                      ; ball touches the paddle M
        ADD G G                      ; G=2*(vertical distance+4) new vertical speed
        NEG G                        ; reflexion
        NEG H                        ; idem
        SMOTION 1 G H                ; new ball motion
        SLOCATE 1 E F               ; new location
        SOUND M                      ; and sound for paddle contact
    ENDIF
ENDIF
RETURN                               ; back to players keys

; end of game

LABEL x
SMAX 0                              ; end of game, stop every sprite
LET R 1                              ; default winner
COMPARE F 124                        ; if position under 124, winner is 2
IF<                                  ; R=2
    INC R
ENDIF
PUTPARAM 4 R                         ; return winner

$$
$END

```

## CHAR ROLL, assembler example

This program makes "roll" every upper case letter from right to left. It uses some assembly instructions to simplify the work.

```
100 CALL CLEAR
$MLC F 110 10 3000
300 INPUT "NUMBER OF ROLLS : ":N
310 CALL LINK("ROLL",N)
320 GOTO 300
$ROLL
  DIMTABLE E 208          ; definitions for 26 letters (26*8)
  BMOVEVTOC 1288 208 E    ; copy defs from VDP ram (1288 = address for A)
  GETPARAM 1 N           ; number of rolls
  NDO N N
    NDO I 8              ; eight bits roll
      $[
        MOV @E,R0        ; R0 = base address E
        LI R1,104        ; R1 = count in words (208 bytes)
        ;
        ; ..."here"...
        ;
        MOV *R0,R2        ; take two bytes ABCDEFGH abcdefgh
        MOV R2,R3         ; a copy of two bytes
        SLA R2,1          ; R2 = BCDEFGHa bcdefgh0 shift left
        ANDI R2,>FEFE     ; R2 = BCDEFGH0 bcdefgh0
        ANDI R3,>8080     ; R3 = A0000000 a0000000
        SRL R3,7          ; R3 = 0000000A 0000000a
        SOC R2,R3         ; R3 = BCDEFGHA bcdefgha (SOC = OR)
        MOV R3,*R0+       ; store circular result
        DEC R1            ; decrement count
        JNE -12           ; not zero, so jump "here"
      $]
      BMOVECTOV E 208 1288 ; new rolled defs in vdp
    NLOOP
  NLOOP
$$
$END
```

## GPU program, how to run the F18A coprocessor

This program show how to run the second processor located into the F18A. The GPU routine fills the screen with "A", then "B", until "Z". The MLC program just runs N times the GPU one.

```
$MLC F 100 10 3000
300 CALL CLEAR
310 INPUT "Number of loops:":N
320 CALL LINK("TEST",N)
330 GOTO 310

;
; here the MLC program that will run "n" times the GPU one
;

$TEST
  GETPARAM 1 N                ; number of loops
  GPURUN &h4000              ; runs GPU program that stops immediately
  NDO I N
    GPUWAKE                  ; wakes up the GPU program
    REPEAT                   ; little loop to wait for the GPU to finish
      GPUSTATE
    UNTIL=                   ; state will be "=" when GPU has finished
  NLOOP
  KEYWAIT 0                  ; wait for a key
$$

;
; here the GPU program in assembly code
; the compiler sends it to VDP location >4000, the new F18A area
; this example fills the screen with the capital letters from A to Z
;

$GPU
  idle                       ; stops the program and wait for WAKE to run
  li r0,26                   ; 26 letters from A to Z
  li r1,>A1A1                 ; start with double >A1 = "A" in XB

  ; letter loop
  clr r2                     ; screen address
  li r3,384                  ; 384 words = 768 bytes = 24*32 positions

  ; fill loop
  mov r1,*r2+                ; write two letters on screen
  dec r3                     ; decrement counter
  jne -3                     ; if not finished, jump to fill loop

  ai r1,>0101                 ; next letter (>A2A2, >A3A3 etc...)
  dec r0                     ; decrement counter
  jne -10                    ; if not finished, jump to letter loop

  b @>4000                  ; back to idle state
$$
$END
```

## BML graphics (F18A only)

This program draws lines filling a square.

*Note the use of XREGENABLE as there is no \$GPU section.*

```
$MLC F 100 10 3000
300 INPUT "How many runs : ":N
310 CALL LINK("TEST",N)
320 END
$TEST
  GETPARAM 1 N ; how many rectangles said the user
  XREGENABLE ; access enabled to extended registers
  STARTDATA
    byte &hE3 ; BML def bloc, flags with palette 3
    byte &h40 ; then address (here 64*64 = 4096)
    bytes 96,64,64,64 ; then x,y,w,h
  ENDDATA E
  BMLSET 0 E ; set my BML without display
  BMLPLOT 0 0 0 ; upper corner
  BMLFILLRECT 64 64 ; clear all
  BMLSET 1 E ; and display the BML
  LET C 3 ; color
  NDO I N
    LET Z 63
    FOR X 0 63 ; first group of lines up to down
      BMLPLOT X 0 C
      BMLDRAWTO Z 63 C
      DEC Z
    NEXT
    LET Z 62
    FOR Y 1 62 ; second group from left to right
      BMLPLOT 63 Y C
      BMLDRAWTO 0 Z C
      DEC Z
    NEXT
    DEC C ; previous color
    AND C 3 ; limited to 0-3
  NLOOP
  PUTTABLE E(0) &h63 ; else, change flags to "BML disabled"
  BMLSET 1 E ; and set new parameters
$$
$END
```

# 7° Table of contents

## 1° Purpose

## 2° How does it work?

### With MLC

F<sub>SIZE</sub> subprogram

P<sub>OP</sub> subprogram

C<sub>OMPIL</sub> subprogram

### With PreCompiler

\$<sub>MLC</sub>

\$<sub>PRGNAM</sub>

\$<sub>SND</sub>

\$<sub>CHAR</sub>

\$<sub>END</sub>

\$<sub>DEL</sub>

## 3° My Little Language

### Variable Initialization

|   |               |
|---|---------------|
| = | let           |
| X | exchange      |
| G | get parameter |
| P | put parameter |

### Arrays

|    |                   |
|----|-------------------|
| TG | table get         |
| TP | table put         |
| TR | table reserve     |
| TM | copy bloc bytes   |
| TW | copy bloc words   |
| TC | copy from CPU     |
| TV | copy from VDP     |
| TO | init one byte     |
| TT | init one word     |
| TH | init hex bytes    |
| TS | init one string   |
| TJ | jump over bytes   |
| TE | make pointer even |
| T< | store pointer     |
| T> | recall pointer    |

## Arithmetic Instructions

|   |                     |
|---|---------------------|
| D | decrement           |
| I | increment           |
| A | absolute            |
| N | negate              |
| Z | set to zero         |
| + | add                 |
| - | sub                 |
| / | div                 |
| * | mul                 |
| R | random              |
| W | word sign extension |

## Floating point

|    |                  |
|----|------------------|
| `@ | reserve floats   |
| `G | get float        |
| `P | put float        |
| `+ | add floats       |
| `- | sub floats       |
| `* | mul floats       |
| `/ | div floats       |
| `^ | power            |
| `C | cosine           |
| `S | sine             |
| `T | tangent          |
| `A | arctangent       |
| `Q | square root      |
| `E | exponential      |
| `L | logarithm        |
| `I | integer part     |
| `N | negate           |
| `B | absolute value   |
| `? | float compare    |
| `F | integer to float |
| `Z | float to integer |

## Joystick and Keyboard

|   |               |
|---|---------------|
| K | read keyboard |
| J | read joystick |

## Compare and Jump

|    |                      |
|----|----------------------|
| L  | set label            |
| _  | kill label           |
| B  | branch to label      |
| S  | branch to subroutine |
| :  | sub label            |
| ;  | sub end              |
| C  | compare              |
| ?= | jump if =            |
| ?> | jump if >            |
| ?< | jump if <            |
| != | jump if <>           |
| !> | jump if <=           |
| !< | jump if >=           |
| (  | check limits         |
| E  | end                  |
| [  | select structure     |
| %  | case                 |
| ]  | endselect            |

## Screen Instructions

|    |                    |
|----|--------------------|
| &G | get character      |
| &P | put character      |
| &C | set color          |
| &S | set screen color   |
| &D | define character   |
| &d | extended def char  |
| &X | extended chars     |
|    | Pattern discussion |

## Sprites

|    |                      |
|----|----------------------|
| #A | set sprite pattern   |
| #C | set sprite color     |
| #L | set sprite location  |
| #M | set sprite motion    |
| #P | get sprite position  |
| #& | change coordinates   |
| #D | get sprites distance |
| #I | enable interrupts    |
| #K | delete sprite        |
| #< | max moving sprites   |

## Logical instructions

|    |                        |
|----|------------------------|
| HA | logical AND            |
| HO | logical OR             |
| HX | logical XOR            |
| HN | logical NOT            |
| HW | swap bytes             |
| H< | shift left arithmetic  |
| H> | shift right arithmetic |
| HL | shift right logical    |
| HR | rotate right           |
| HC | carry bit              |

## Set instructions

|    |                   |
|----|-------------------|
| FD | define set        |
| F+ | add element       |
| F- | remove element    |
| F? | test element      |
| FZ | clear set         |
| FO | fill set          |
| FN | complement        |
| FC | cardinal          |
| FF | find next element |
| FU | set union         |
| FI | set intersection  |
| FX | set difference    |

## Music, Sound, Speech

|    |                  |
|----|------------------|
| &M | play sound       |
|    | Sound discussion |
| &T | say rom word     |
| &? | is talking?      |
| &U | say user word    |

## Debugging

|              |                    |
|--------------|--------------------|
| M            | display a variable |
| [ , ] , \    | pseudo variables   |
| #XX          | debugging flags    |
| DEBUG_BUFFER |                    |
| DEBUG_LINE   |                    |
| DEBUG        |                    |

## **File access**

PAB discussion  
Y file operation  
Y0 open  
Y1 close  
Y2 read  
Y3 write  
Y4 restore  
Y5 load  
Y6 save  
Y7 delete  
Y8 scratch  
Y9 status

## **F18A support**

QV write VDP reg  
QR run VDP prog  
QW wake VDP prog  
QS sleep VDP prog  
Q? GPU state  
QB set BML  
QP plot a pixel  
QD draw to  
QF fill rectangle  
QT manage timer  
&w TEXT mode  
&w Multicolor mode  
&p plot in multicolor  
&l draw in multicolor

## **4° Precompiler unique features**

### **Pseudo instructions**

NDO .. NLOOP  
N0DO .. N0LOOP  
N-1DO .. N-1LOOP  
FOR .. NEXT  
REPEAT .. UNTIL*test*  
DO .. WHILE*test* .. LOOP  
IF*test* .. ENDIF  
IF*test* .. ELSE .. ENDIF

### **Inline Assembler**

\$( .. \$)  
DATA BYTE EVEN  
LABEL GOTO  
Note on addressing modes  
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## **5° Error Codes**

## **6° Examples**

PI calculation  
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