**Enhanced 65816 BASIC reference manual**

**Preface**

The manual this was based on was compiled in October 2013 from a snapshot of Lee Davison’s website http://mycorner.no-ip.org/6502/ehbasic/index.html after it had been off air for quite a while.

Most of the content of this manual is the sole intellectual property of the original author Lee Davison. See the copyright notice in the introduction, for what you can and what you cannot do with the source code and with the documentation. Conversion to run on the WE816 platform and the associated disk, graphics, and sound commands was done by Dan Werner.

**Content**

[The original Enhanced 6502 BASIC By Lee Davison 2](#_Toc88399891)

[Introduction 2](#_Toc88399892)

[EhBasic 65C816 Port 2](#_Toc88399893)

[Enhanced BASIC language reference 3](#_Toc88399894)

[BASIC Keywords 4](#_Toc88399895)

[Manual Conventions 5](#_Toc88399896)

[BASIC Commands 5](#_Toc88399897)

[BASIC Operators 16](#_Toc88399898)

[BASIC Functions 16](#_Toc88399899)

[BASIC Error Messages 20](#_Toc88399900)

[Enhanced BASIC, advanced examples 22](#_Toc88399901)

[Enhanced BASIC, extending CALL 31](#_Toc88399902)

[Enhanced BASIC, using USR() 33](#_Toc88399903)

[Enhanced BASIC internals 39](#_Toc88399904)

[Enhanced BASIC, useful routines 42](#_Toc88399905)

[WE816 Hardware Reference 46](#_Toc88399906)

[Screen Font 49](#_Toc88399907)

[Musical Note to “Frequencies” 50](#_Toc88399908)

[Memory Map 54](#_Toc88399909)

# The original Enhanced 6502 BASIC By Lee Davison

## Introduction

Enhanced BASIC is a BASIC interpreter for the 6502 and compatible microprocessors. It is constructed to be quick and powerful and easily ported to most 6502 systems. It requires few resources to run and includes instructions to facilitate easy low level handling of hardware devices. It also retains most of the powerful high level instructions from similar BASICs.

EhBASIC represents hundreds of hours work over nearly three years, lots of frustration, lots of joy and the occasional twinge from RSI induced tendonitis.

EhBASIC is free but not copyright free. For non commercial use there is only one restriction, any derivative work should include, in any binary image distributed, the string "Derived from EhBASIC" and in any distribution that includes human readable files a file that includes the above string in a human readable form e.g. not as a comment in an HTML file.

## EhBasic 65C816 Port

## 

EhBASIC was ported to the 65816 CPU on the WE816 computer. It is designed to allow a full 64K bank for BASIC code and variables with the BASIC interpreter running in a totally different bank. Program Bank, Data Bank and Stack parameters can be adjusted in the definitions.asm file included in the archive, and zero page usage can be found in the zeropage.asm file.

# Enhanced BASIC language reference

***Numbers***

Numbers may range from zero to plus or minus 1.70141173x10^38 and will have an accuracy of just under 1 part in 1.68 x 10^7.

Numbers can be preceded by a sign, + or -, and are written as a string of numeric digits with or without a decimal point and can also have a positive or negative exponent as a power of 10 multiplier e.g.

-142 96.3 0.25 -136.42E-3 -1.3E7 1

.. are all valid numbers.

Integer numbers, i.e. with no decimal fraction or exponent, can also be in either hexadecimal or binary. Hexadecimal numbers should be preceded by **$** and binary numbers preceded by **%**, e.g.

%101010 -$FFE0 $A0127BD -%10011001 %00001010 $0A

.. again are all valid numbers.

***Strings***

Strings are any string of printable characters enclosed in a pair of quotation marks. Non printing characters may be converted to single character strings using the CHR$() functions.

"Hello world" "-136.42E-3" "+----+----+" "[Y/n]" "Y"

Are all valid strings.

***Variables***

Variables of both numeric and string type are available. String variables are distinguished by the **$** suffix. As well as simple variables arrays are also available and these may be either numeric or string and are distinguished by their bracketed indices after the variable name.

Variable names may be any length but only the first two name characters are significant so BL and BLANK will refer to the same variable. The first character must be one of "A" to "Z" or "a" to "z", following characters may also include numbers. E.g.

A A$ NAME$ x2LIM y colour s1 s2

Variable names are case sensitive so AB, Ab, aB and ab are all separate variables.

Variable names may not contain BASIC keywords. Keywords are only valid in upper case so 'PRINTER' is not allowed (it would be interpreted as PRINT ER) but 'printer' is.

Note that spaces in variable names are ignored so 'print e r', 'print er' and 'pri nter' will all be interpreted the same way.

### BASIC Keywords

Here is a list of BASIC keywords. They are only valid when entered in upper case as shown and spaces may not be included in them. So GOTO is a valid BASIC keyword but GO TO is not.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ABS | AND | ASC | ATN | BIN$ | BITCLR |
| BITSET | BITTST | CALL | CHR$ | CLEAR | CLOSE |
| COLOR | CON | CONT | COS | DATA | DEC |
| DEEK | DEF | DIM | DIRECTORY | DISKCMD | DISKSTATUS |
| DO | ELSE | END | EOR | EXP | FN |
| FOR | FRE | GET# | GET | GOSUB | GOTO |
| HEX$ | IECINPUT | IECOUTPUT | IECST | IF | INC |
| INPUT | INT | LCASE$ | LEFT$ | LEN | LET |
| LIST | LOAD | LOCATE | LOG | LOOP | MAX |
| MID$ | MIN | MONITOR | NEW | NEXT | NOISE |
| NOT | NULL | OFF | ON | OPEN | OR |
| PATTERN | PEEK | PI | PLOT | POKE | POS |
| PRINT | PUT# | READ | REM | RESTORE | RETURN |
| RIGHT$ | RND | RUN | SADD | SAVE | SCNCLR |
| SCREEN | SGN | SIN | SOUND | SPC | SPEEK |
| SPOKE | SPRDEF | SPRITE | SPRSIZE | SQR | STEP |
| STOP | STR$ | SWAP | SYS | TAB | TAN |
| THEN | TO | TONE | UCASE$ | UNTIL | USR |
| VAL | VARPTR | VOICE | VOLUME | WAIT | WHILE |
| WIDTH | \* | + | - | / | << |
| = | >> | < | > |  |  |

### Manual Conventions

* Anything in upper case is part of the command/function structure and must be present
* Anything in lower case enclosed in < > is to be supplied by the user
* Anything enclosed in [ ] is optional
* Anything enclosed in { } and separated by | characters are multi choice options
* Any items followed by an ellipsis, ... , may be repeated any number of times
* Any punctuation and symbols, except those above, are part of the structure and must be included
* var is a valid variable name
* var$ is a valid string variable name
* var() is a valid array name
* var$() is a valid string array name
* expression is any expression returning a result
* expression$ is any expression returning a string result
* addr is an integer in the range +/- 16777215 that will be wrapped to the range 0 to 65535
* b is a byte value 0 to 255
* n is an integer in the range 0 to 63999 w is an integer in the range -32768 to 32767
* i is a positive integer value
* r is real number
* +r is a positive value real number (0 is considered positive)
* $ is a string literal

### BASIC Commands

#### BITCLR <addr>,<b>

Clears bit b of address addr. Valid bit numbers are 0, the least significant bit, to 7, the most significant bit. Values outside this range will cause a function call error.

#### BITSET <addr>,<b>

Sets bit b of address addr. Valid bit numbers are 0, the least significant bit, to 7, the most significant bit. Values outside this range will cause a function call error.

#### CALL <addr>

CALLs a user subroutine at address addr. No values are passed or returned and so this is much faster than using USR(). See extending CALL for details.

#### CLEAR

Erases all variables and functions and resets FOR .. NEXT, GOSUB .. RETURN and DO ..LOOP states.

#### CLOSE <Logical file b>

Close IEC logical File <b>. See Working with Files for more information.

#### COLOR <background b>,<foreground b>

Sets the background and foreground colors on the text screen.

1. Transparent
2. Black
3. Medium Green
4. Light Green
5. Dark Blue
6. Light Blue
7. Dark Red
8. Cyan
9. Medium Red
10. Light Red
11. Dark Yellow
12. Light Yellow
13. Dark Green
14. Magenta
15. Grey
16. White

#### CONT

Continues program execution after CTRL-C has been typed, a STOP has been encountered during program execution or a null input was given to an INPUT request.

#### DATA [{r|$}[,{r|$}]...]

Defines a constant or series of constants. Real constants are held as strings in program memory and can be read as numeric values or string values. String constants may contain spaces but if they need to contain commas then they must be enclosed in quotes.

**DEC <var>[,var]...**

Decrement variables. The variables listed will have their values decremented by one. Trying to decrement a string variable will give a type mismatch error. DEC A is much faster than doing A=A-1 and DEC A,A is slightly faster than doing A=A-2.

#### DEF FN <name>(<var>) = <statement>

Defines <statement> as function <name>. <name> can be any valid numeric variable name of one or more characters. <var> must be a simple variable and is used to pass a numeric argument into the function.

Note that the value of <var> will be unchanged if it is used in the function so <var> should be considered to be a local variable name.

**DIM <var[$](i1[,i2[,in]...])>[,var[$](i1[,i2[,in]...])]...**

Dimension arrays. Creates arrays of either string or numeric variables. The arrays can have one or more dimensions. The lower limit of any dimension is always zero and the upper limit is i. If you do not explicitly dimension an array then it's number of dimensions will be set when you first access it and the upper bound will be set to 10 for each dimension.

#### DIRECTORY <IEC DEVICE b>

Prints the disk directory from device <b>.

#### DISKCMD <command$>,<IEC DEVICE b>

Sends the disk command to device b. See the disk device documentation for a list of commands and syntax.

***Example:* DISKCMD “S0:FILENAME”,8**

**DO**

Marks the beginning of a DO .. LOOP loop (See LOOP). No parameters. This command can be nested like FOR .. NEXT or GOSUB .. RETURN.

**ELSE**

See IF.

#### END

Terminates program execution and returns control to the command line (direct mode). END may be placed anywhere in a program, it does not have to be on the last line, and there may be any number, including none, of ENDs in total.

Note. CONT may be used after an END to resume execution from the next statement.

**FN<name>(<expression>)**

See DEF.

#### FOR <var> = <expression> TO <expression> [STEP expression]

Assigns a variable to a loop counter and optionally sets the start value, the end value and the step size. If STEP expression is omitted then a default step size of +1 will be assumed.

#### GET# <Logical File b>,<var[$]>

Gets a character, if there is one, from the input channel <b>. This command must be preceded by OPEN and IECINPUT commands. See Working with Files for more information.

#### GET <var[$]>

Gets a key, if there is one, from the input device. If there is no key waiting then var will be set to 0 and var$ will return a null string "". GET does not halt and execution will continue.

#### GOSUB <n>

Call a subroutine at line n. Program execution is diverted to line n but the calling point is remembered. Upon encountering a RETURN statement program execution will continue with the next statement (line) after the GOSUB.

**GOTO <n>**

Continue execution from line number n.

**IECINPUT <Logical File** **b>**

Designate IEC channel <b> as input. See Working with Files for more information.

**IECOUTPUT <Logical File** **b>**

Designate IEC channel <b> as output. See Working with Files for more information.

#### IF <expression> {GOTO<n>|THEN<{n|statement}>}[ELSE<{n|statement}>]

Evaluates expression. If the result of expression is non zero then the GOTO or the statement after the THEN is executed. If the result of expression is zero then execution continues with the next line.

If the result of expression is zero and the optional ELSE clause is included then the statement after the ELSE is executed.

IF .. THEN .. ELSE .. behaves as a single statement so in the line ..

IF <expression> THEN <statement one> ELSE <statement two> :

<statement three>

.. statement three will always be executed regardless of the outcome of the IF as long as the executed statement was not a GOTO.

**INC <var>[,var]...**

Increment variables. The variables listed will have their values incremented by one. Trying to increment a string variable will give a type mismatch error. INC A is much faster than doing A=A+1 and INC A,A is slightly faster than doing A=A+2.

**INPUT ["$";] <var>[,var]...**

Get a variable, or list of variables from the input stream. A question mark, "?", is always output, after the string if there is one, and if further input is required, i.e. there are more variables in the list than the user entered values, then a double question mark, "??", will be output until enough values have been entered.

There are two possible messages that may appear during the execution of an input statement:

##### Extra ignored

The user has attempted to enter more values than are required. Program execution will continue but the extraneous data entered has been discarded.

##### Redo from start

The user has attempted to enter a string where a number was expected. The reverse never causes an error as numbers are also valid strings.

#### LET <var> = <expression>

Assign the value of expression to var. Both var and expression bust be of the same type. The LET command word is optional and just <var> = <expression> will give exactly the same result. It is only maintained for historical reasons.

#### LIST [n1][-n2]

Lists the entire program held in memory. If n1 is specified then the listing will start from line n1 and run to the end of the program. If -n2 is specified then the listing will terminate after line n2 has been listed. If n1 and -n2 are specified then all the lines from n1 to n2 inclusive will be listed.

Note. If n1 does not exist then the list will start from the next line numbered after n1. If n2 does not exist then the listing will stop with the last line numbered before n2.

Also note. LIST can be executed from within a program, first a [CR][LF] is printed and then the specified lines, if any, each terminated with another [CR][LF]. Program execution then continues as normal.

**LOAD** **var[$] ,<b>**

Load a program named var[$] from IEC channel <b>.

#### LOOP [{UNTIL|WHILE} expression]

Marks the end of a DO .. LOOP loop. There are three possible variations on the LOOP command ..

#### LOOP

This loop repeats forever. With just this command control is passed back to the next command after the corresponding DO.

#### LOOP UNTIL expression

This loop will repeat until the value of expression is non zero. Once that occurs execution will continue with the next command after the LOOP UNTIL.

#### LOOP WHILE expression

This loop will repeat while the value of expression is non zero. When the value of expression is zero execution will continue with the next command after the LOOP WHILE.

**MONITOR**

Exit to the system monitor. See WE816 system documentation for more information on how to use the system monitor.

**NEW**

Deletes the current program and all variables from memory.

#### NEXT [var[,var]...]

Increments or decrements a loop variable and checks for the terminating condition. If the terminating condition has been reached then execution continues with the next command, else execution continues with the command after the FOR assignment. *See FOR*.

**NOISE <channel b>,<noise period b>**

Selects a given channel (0-2) to generate NOISE, rather than TONE, and configures the noise period.

**NOT <expression>**

Generates the bitwise NOT of then signed integer value of <expression>.

#### NULL <n>

Sets the number of null characters printed by BASIC after every carriage return. n may be specified in the range 0 to 255.

**ON <expression> {GOTO|GOSUB} <n>[,n]...**

The integer value of expression is calculated and then the nth number after the GOTO or GOSUB is taken (where n is the result of expression). Note that valid results for expression range only from zero to 255. Any result outside this range will cause a Function call error.

#### OPEN <Logical File b>,<IEC Device Number b>,<Secondary Address b>,<file name var[$]>

Open a file to an IEC Device. See Working with Files for more information.

**PATTERN <pattern number b>,<Color b>, <b>,<b>,<b>,<b>, <b>,<b>,<b>,<b>**

Defines Pattern for a graphics Character. See Working with Graphics for more information.

**PLOT <b>,<b>,<b>,<b>**

Video Mode 0 and 3:

Plot a pattern to the screen X,Y,Pattern

Video Mode 1:

Plot a pixel to the screen X,Y,Color

Video Mode 4:

Plot a pixel to the screen X,Y,Priority,Color.

See Working with Graphics for more information.

**POKE <addr,b>**

Writes the byte value b into the address addr.

#### PRINT [expression][{;|,}expression]...[{;|,}]

Outputs the value of each expressions. If the list of expressions to be output does not end with a comma or a semi-colon, then a carriage return and linefeed is output after the values.

Expressions on the line can be separated with either a semi-colon, causing the next expression to follow immediately, or a comma which will advance the output to the next tab stop before continuing to print. If there are no expressions and no comma or semi-colon after the PRINT statement then a carriage return and linefeed is output.

When entering a program line, or immediate statement, PRINT can be abbreviated to ?

#### PUT# <Logical File b>,<var[$]>

Outputs the char value to IEC channel <b>. This must be preceded with Open and IECOUTPUT commands. See Working with Files for more information.

**READ <var>[,var]...**

Reads values from DATA statements and assigns them to variables. Trying to read a string literal into a numeric variable will cause a syntax error.

**REM**

Everything following this statement on this program line will be ignored, even colons.

#### RESTORE [n]

Reset the DATA pointer. If n is specified then the pointer will be reset to the beginning of line n else it will be reset to the start of the program. If n is specified but doesn't exist an error will be generated.

#### RETURN

Returns program execution to the next statement (line) after the last GOSUB encountered. See GOSUB. Also returns program execution to the next statement after an interrupt but does not restore the enabled flags.

#### RUN [n]

Begins execution of the program currently in memory at the lowest numbered line. RUN erases all variables and functions, resets FOR .. NEXT, GOSUB .. RETURN and DO ..LOOP states and sets the data pointer to the program start.

If n is specified then programme execution will start at the specified line number.

#### SAVE <var[$]>,<b>

Save the program in memory to filename <$> on IEC Device <b>.

#### SCNCLR

Clear the Text Screen.

#### SCREEN <b>

Set the graphics screen mode. Note that this will only change modes within a running basic program, immediate mode must always be in the text screen mode. See Working with Graphics for more information.

1. Graphics Mode (32x24 patterns)
2. Multicolor (64x64 blocks)
3. Text Mode (40x24)

4 Hires Graphics Mode (256x192)

**SOUND <channel b>, <frequency var>**

Play a sound on channel (0-2), at the frequency var. See Appendix for musical note to frequency values. Note that “frequency” does not equate to actual frequency of the note provided.

**SPC(<expression>)**

Prints <expression> spaces. This command is only valid in a PRINT statement.

**SPOKE <addr>,<b>**

Poke a value <b> into screen memory at address <addr>.

**SPRDEF <b>,<b>** . . . <b>

Define a sprite pattern <b>, followed by a pattern of 8 bytes.

**SPRITE <Sprite #b>,<Sprite Pattern b>,<X b>,<Y b>,<Color b>,<LeftShift b>**

Set sprite parameters, SpriteNum,SpritePattern,X,Y,Color,LeftShift(0/1). See Working with Sprites for more information.

**SPRSIZE <b>**

Set Sprite sizes.

1. 8x8 Sprites, 1x magnification
2. 8x8 Sprites, 2x magnification
3. 16x16 Sprites, 1x magnification
4. 16x16 Sprites, 2x magnification

**STEP**

Sets the step size in a FOR .. NEXT loop. See FOR.

#### STOP

Halts program execution and generates a "Break in line n" message where n is the line in which the STOP was encountered.

#### SWAP <var[$]>,<var[$]>

Swap two variables. The variables listed will have their values exchanged. Both must be of the same type, numeric or string, and either, or both, may be array elements. Trying to swap a numeric and string variable will give a type mismatch error.

#### TAB(<expression>)

Sets the cursor position to <expression>. If the cursor is already beyond that point then the cursor will be left where it is. This command is only valid in a PRINT statement.

**THEN**

See IF.

**TO**

Sets the range in a FOR .. NEXT loop. See FOR.

**TO**NE <channel b>

Sets the channel (0-2) to generate TONEs rather than NOISE.

**UNTIL**

See DO and LOOP.

#### VOICE <shape b>,<period var>

Set the envelope generator on the chip to a given shape, and period (duration of one cycle).

Shapes:

|  |  |
| --- | --- |
| 0 |  |
| 4 |  |
| 8 |  |
| 9 |  |
| 10 |  |
| 11 |  |
| 12 |  |
| 13 |  |
| 14 |  |
| 15 |  |

#### VOLUME <channel b>,<volume b>

Set the volume of a given channel (0-2) to <B>.

For solid tones, use values 0-15. To use the envelope generator on the chip, use values 16-31.

#### WAIT <addr,b1>[,b2]

Program execution will wait at this point until the value of the location addr exclusive ORed with b2 then ANDed with b1 is non zero. If b2 is not defined then it is assumed to be zero. Note b1 and b2 must both be byte values.

**WHILE**

See DO and LOOP.

#### WIDTH {b1|,b2|b1,b2}

Sets the terminal width and TAB spacing. b1 is the terminal width and b2 is the tab spacing, default is 80 and 14. Width can be zero, for "infinite" terminal width, or from 16 to 255. The tab size is from 2 to width-1 or 127, whichever is smaller.

### BASIC Operators

Operators perform mathematical or logical operations on values and return the result. The operation is usually preceded by a variable name and equality sign or is part of an IF .. THEN statement.

+ Add. c = a + b will assign the sum of a and b to c.

- Subtract. c = a - b will assign the result of a minus b to c.

\* Multiply. c = a \* b will assign the product of a and b to c.

/ Divide. c = a / b will assign the result of a divided by b to c.

^ Raise to the power of. c = a ^ b will assign the result of a raised to the power of b to c.

AND Logical AND. c = a AND b will assign the logical AND of a and b to c

EOR Logical Exclusive OR. c = a EOR b will assign the logical exclusive OR of a and b to c.

OR Logical OR. c = a OR b will assign the logical inclusive OR of a and b to c.

<< Shift left. c = a << b will assign the result of a shifted left by b bits to c.

>> Shift right. c = a >> b will assign the result of a shifted right by b bits to c.

= Equals. c = a = b will assign the result of the comparison a = b to c.

> Greater than. c = a < b will assign the result of the comparison a > b to c.

< Less than. c = a < b will assign the result of the comparison of a < b to c.

The three comparison operators can be mixed to provide further operators ..

>= or => Greater than or equal to.

<= or =< Less than or equal to.

<> or >< Not equal to (greater than or less than).

<=> any order Always true (greater than or equal to or less than).

### BASIC Functions

Functions always return a value, be it numeric or string, so are used on the right hand side of the = sign in assignments, on either side of operators and in commands requiring an expression e.g. after PRINT, within expressions, or in other functions.

**ABS(<expression>)**

Returns the absolute value of <expression>.

**ASC(<expression$>)**

Returns the ASCII value of the first character of <expression$>.

**ATN(<expression>)**

Returns, in radians, the arctangent of <expression>.

#### BIN$(<expression>[,b])

Returns <expression> as a binary string. If b is omitted, or if b = 0, then the string is returned with all leading zeroes removed and is of variable length. If b is set, permissible values range from 1 to 24, then a string of length b will be returned. The result is always unsigned and calling this function with expression > 2^24-1 or b > 24 will cause a function call error.

#### BITTST(<addr>,<b>)

Tests bit b of address addr. Valid bit numbers are 0, the least significant bit, to 7, the most significant bit. Values outside this range will cause a function call error. Returns zero if the bit was zero, returns -1 if the bit was 1.

#### CON(<b>)

Takes game controller number as one parameter (0,1) and returns the state of that game controller. The status of the controller is encoded like this:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **BIT 7** | **BIT 6** | **BIT 5** | **BIT 4** | **BIT 3** | **BIT 2** | **BIT 1** | **BIT 0** |
|  |  | BUTTON B | BUTTON A | RIGHT | LEFT | DOWN | UP |

**COS(<expression>)**

Returns the cosine of the angle <expression> radians.

#### DISKSTATUS(<b>)

Returns the string value of the disk status of device <b>

**EXP(<expression>)**

Returns e^<expression>. Natural antilog.

#### FRE(<expression>)

Returns the amount of free program memory. The value of expression is ignored and can be numeric or string.

#### HEX$(<expression>[,b])

Returns <expression> as a hex string. If b is omitted, or if b = 0, then the string is returned with all leading zeroes removed and is of variable length. If b is set, permissible values range from 1 to 6, then a string of length b will be returned. The result is always unsigned and calling this function with expression > 2^24-1 or b > 6 will cause a function call error.

**IECST(<b>)**

Returns the IEC status of channel <b>.

**INT(<expression>)**

Returns the integer of <expression>.

**LCASE$(<expression$>)**

Returns <expression$> with all the alpha characters in lower case.

**LEFT$(<expression$,b>)**

Returns the leftmost b characters of <expression$>.

**LEN(<expression$>)**

Returns the length of <expression$>.

**LOG(<expression>)**

Returns the natural logarithm (base e) of <expression>.

#### MAX(<expression>[,<expression>]...)

Returns the maximum value from a list of numeric expressions. There must be at least one expression but the upper limit is dictated by the line length. Each expression is evaluated in turn and the largest of them returned.

#### MID$(<expression$,b1>[,b2])

Returns the substring string from character b1 of expression$ of length b2. The characters of expression$ are numbered from 1 starting with the leftmost. If b2 is omitted then all the characters from b1 to the end of the string are returned.

#### MIN(<expression>[,<expression>]...)

Returns the minimum value from a list of numeric expressions. There must be at least one expression but the upper limit is dictated by the line length. Each expression is evaluated in turn and the smallest of them returned.

**PEEK(<addr>)**

Returns the byte value of <addr>.

**PI**

Returns the value of pi as 3.14159274 (closest floating value).

**POS(<expression>)**

Returns the POSition of the cursor on the terminal line. The value of expression is ignored.

**RIGHT$(<expression$,b>)**

Returns the rightmost b characters of <expression$>.

#### RND(<expression>)

Returns a random number in the range 0 to 1. If the value of <expression> is non zero then it will be used as the seed for the returned pseudo random number otherwise the next number in the sequence will be returned.

#### SADD(<{var$|var$()}>)

Returns the address of var$ or var$(). This returns a pointer to the actual string in memory not the descriptor. If you want the pointer to the descriptor use VARPTR instead.

#### SGN(<expression>)

Returns the sign of <expression>. If the value is positive SGN returns +1, if the value is negative then SGN returns -1. If expression=0 then SGN returns 0.

**SIN(<expression>)**

Returns the sine of the angle <expression> radians.

**SPEEK (<addr>)**

Return the value at screen memory address <addr>.

**SQR(<expression>)**

Returns the square root of <expression>.

**STR$(<expression>)**

Returns the result of <expression> as a string.

**TAN(<expression>)**

Returns the tangent of the angle <expression> radians.

**UCASE$(<expression$>)**

Returns <expression$> with all the alpha characters in upper case.

**CHR$(b)**

Returns single character string of character <b>.

#### USR(<expression>)

Takes the value of <expression> and places it in FAC1 and then calls the USeR routine pointed to by the vector at $0B,$0C. What the routine does with this value is entirely up to the user, it can even be safely ignored if it isn't needed. The routine, after the user code has done an RTS, takes whatever is in FAC1 and returns that. Note it can be either a numeric or string value. See using USR() for details.

If no value needs to be passed or returned then CALL is a better option.

**VAL(<expression$>)**

Returns the value of <expression$>.

#### VARPTR(<var[$]>)

Returns a pointer to the variable memory space. If the variable is numeric, or a numeric array element, then VARPTR returns the pointer to the packed value of that variable in memory. If the variable is a string, or a string array element, then VARPTR returns a pointer to the descriptor for that string. If you want the pointer to the string itself use SADD instead.

### BASIC Error Messages

These all occur from time to time and, if the error occurred while executing a program, will be followed by "in line " where is the number of the line in which the error occurred.

##### Array bounds Error

An attempt was made to access an element of an array that was outside it's bounding dimensions.

##### Can't continue Error

Execution can't be continued because either the program execution ended because an error occurred, NEW or CLEAR have been executed since the program was interrupted or the program has been edited.

***Divide by zero Error***

The right hand side of an A/B expression was zero.

##### Double dimension Error

An attempt has been made to dimension an already dimensioned array. This could be because the array was accessed previously causing it to be dimensioned by default.

##### Function call Error

Some parameter of a function was outside it's limits. E.g. Trying to POKE a value of less than 0 or greater than 255.

##### Illegal direct Error

An attempt was made to execute a command or function in direct mode which is disallowed in that mode e.g. INPUT or DEF.

***LOOP without DO Error***

LOOP has been encountered and no matching DO could be found.

***NEXT without FOR Error***

NEXT has been encountered and no matching FOR could be found.

##### Out of DATA Error

A READ has tried to read data beyond the last item. Usually because you either mistyped the DATA lines, miscounted the DATA, RESTOREd to the wrong place or just plain forgot to restore.

##### Overflow Error

The result of a calculation has exceeded the numerical range of BASIC. This is plus or minus

1.7014117+E38

##### Out of memory Error

Anything that uses memory can cause this but mostly it's writing and running programmes that does it.

***RETURN without GOSUB Error***

RETURN has been encountered and no matching GOSUB could be found.

##### String too complex Error

A string expression caused an overflow on the descriptor stack. Try splitting the expression into smaller pieces.

***String too long Error***

String lengths can be from zero to 255 characters, more than that and you will see this.

***Syntax Error***

Just generally wrong. 8^)=

##### Type mismatch Error

An attempt was made to assign a numeric value to a string variable, a string value to a numeric variable or a value of one type was returned when a value of the other type was expected or an attempt at a relational operation between a string and a number was made.

***Undefined function Error***

FN <var> was called but not found.

##### Undefined statement Error

Either a GOTO, GOSUB, RUN or RESTORE was attempted to a line that doesn't exist or the line referred to in an ON <expression> {GOTO|GOSUB} or ON {IRQ|NMI} doesn't exist.

## Enhanced BASIC, advanced examples

***Working with Files.***

The following is an example BASIC program that writes and reads back a sequential file to the Commodore 1541 Disk Drive. For more advanced drive functions, please see the reference guide for the IEC device you are communicating with.

10 OPEN 3,8,4,"TFI2,SEQ,W"

20 IECOUTPUT 3

30 PUT#3,"OUT"+CHR$(13)

31 PUT#3,"OUT1"+CHR$(13)+CHR$(5)

32 PUT#3,"OUT2"+CHR$(13)+CHR$(10)+CHR$(5)

40 CLOSE 3

70 OPEN 4,8,8,"TFI2,SEQ,R"

80 IECINPUT 4

90 GET#4,A

100 PRINT A, IECST

101 IF IECST=0 THEN GOTO 90

110 CLOSE 4

***Working with Sound.***

The AY-3-8910 sound chip is a simple (by today’s standards) sound generation chip. It contains 3 voices that can be configured as either tone or noise, and has a simple envelope generator. More specific information on the AY-3-8910 can be found online or in the AY-3-8910 datasheet.

Here are a few sample BASIC programs to generate a series of tones from the WE816.

Program 1:

5 REM SIMPLE SERIES OF TONES ON VOICE 0

10 VOLUME 0,15

20 TONE 0

30 I=100

30 FOR I = 100 TO 4000 STEP 100

40 SOUND 0,I

50 FOR X = 0 TO 500: NEXT X

60 NEXT I

1. SOUND 0,0

Program 2:

4 REM MORE COMPLEX SOUNDS USING THE ENVELOPE

6 REM GENERATOR AND A SAWTOOTH WAVEFORM

10 VOLUME 0,31

20 TONE 0

25 VOICE 8,2000

30 FOR I = 100 TO 4000 STEP 100

40 SOUND 0,I

50 FOR X = 0 TO 500: NEXT X

60 NEXT I

70 SOUND 0,0

***Working with Graphics.***

EhBasic supports working with graphics in 3 modes, on the WE816.

* 0 - Graphics Mode (32x24 tiled patterns)
* 1 - Multicolor (64x64 blocks)
* 4 - Hires Graphics Mode (256x192)

Each mode has different constraints and a different mode of operation. Note that graphics modes can only be accessed from inside a running BASIC program. Direct mode operation is not allowed.

Mode 0 Example:

10 SCREEN 0 ***Set screen mode 0***

20 REM BUILD A GRAPHICS PATTERN

30 PATTERN 1,5,255,0,255,0,255,0,255,0 ***Define a pattern***

40 PLOT 5,5,1 ***Place the pattern on the screen***

50 INPUT G$ ***Wait!! (stop program from exiting out of graphics mode)***

Mode 1 Example:

10 SCREEN 1 ***Set screen mode 1***

20 PLOT 5,5,3 ***Place A block on the screen (location 5,5 color 3)***

30 PLOT 6,6,4 ***Place A block on the screen (location 6,6 color 4)***

40 PLOT 7,7,5 ***Place A block on the screen (location 7,7 color 5)***

50 INPUT G$ ***Wait!! (stop program from exiting out of graphics mode)***

Mode 4 Example:

10 SCREEN 4 ***Set screen mode 4***

20 PLOT 5,5,0,3 ***Place A block on the screen (location 5,5 color 3)***

30 PLOT 6,6,0,4 ***Place A block on the screen (location 6,6 color 4)***

40 PLOT 7,7,0,5 ***Place A block on the screen (location 7,7 color 5)***

50 INPUT G$ ***Wait!! (stop program from exiting out of graphics mode)***

***Working with Sprites.***

Sprites are a powerful feature of the TMS9918 graphics chip. All modes except for 2 can render sprites. There can be up to 32 monochrome sprites of either 8×8 or 16×16 pixels on screen, each sprite with its own, single color. The illusion of multicolor sprites can be created by stacking multiple sprites on top of each other. There can be no more than 4 sprites on a single scanline; any additional sprites' horizontal pixels are dropped. Sprites with a higher priority are drawn first. See the TI TMS9918 programmers guide for more information on sprites.

10 SCREEN 1 ***place the system in a graphics mode, no sprites in mode 2.***

20 SPRDEF 0,255,0,255,0,255,0,255,0 ***define sprite patten 0***

30 SPRSIZE 0 ***set 1x 8x8 sprites***

40 FOR I = 0 TO 255 ***let’s loop to move our sprite! (location 7,7 color 5)***

50 SPRITE 0,0,I,40,3,0 ***Place sprite 0, pattern 0 at I,40 on the screen color 3***

60 NEXT I ***loop!***

70 GOTO 40 ***Rinse and repeat***

***Creating buffer space.***

Sometimes there is a need for a byte oriented buffer space. This can be achieved by lowering the top of BASIC memory and using the "protected" space created thus. The main problem with this is that there may not be the same RAM configuration in all the systems this code is to run on.

One way round this is to allocate the space from BASIC's array memory by dimensioning an array big enough to hold your data. As arrays always start from zero then to work out the array size needed you do ..

Array dimension = (bytes needed/4)-1. E.g.

10 DIM b1(19) : REM need 80 bytes for input buffer

20 DIM b2($100) : REM need $0400 bytes for screen buffer

So you've allocated the buffer but where is it? This is one use of the VARPTR function, it is used in this case to return the start of the array's data space.

E.g.

100 a1 = VARPTR(b1(0)) : REM get the address of the buffer space

But wait, there is another problem here. Because variables are created when they are first assigned a value any new variable created after the array is dimensioned will move the array in memory. So the following will not work..

|  |
| --- |
| 10 DIM b1(19) : REM 80 bytes for buffer  20 a1 = VARPTR(b1(0)) : REM get the address of the buffer space  40 FOR x = 0 to 79  50 POKE a1+x,ASC(" ") 60 NEXT  .  . |

When we get to line 40, a1, the pointer to the array data space, is wrong because the variable x has been created and moved all the arrays up by six bytes. The way round this is to ensure that all variables that you will use have been created prior to getting the pointer. This also means you start with known values in all your variables.

|  |
| --- |
| 10 DIM b1(19) : REM 80 bytes for buffer  20 x = 0 : REM loop counter  30 a1 = VARPTR(b1(0)) : REM get the address of the buffer space  40 FOR x = 0 to 79  50 POKE a1+x,ASC(" ") 60 NEXT  .  . |

Another way is to get the pointer every time you use it. This has the advantage of always being correct but is somewhat slower.

|  |
| --- |
| 10 DIM b1(19) : REM 80 bytes for buffer  40 FOR x = 0 to 79  50 POKE VARPTR(b1(0))+x,ASC(" ") 60 NEXT  .  . |

One thing to remember, never try to use a string array as a buffer. Everything will seem to work until you run out of string space and the garbage collection routine is called. Once this happens it's likely that your buffer will get trashed and you may even find that the program freezes because the garbage collection routine now thinks that there are more string bytes than there are memory.

***Creating short code space.***

While the techniques explained above can also be used to create space for machine code routines there is a simpler way for position independent routines up to 255 bytes long to be held in memory.

Assemble the code and use the hex output from your assembler to create a set of BASIC data statements.

E.g.

1000 DATA $A5,$11,$C9,$3A,$B0,$08,$38,$E9

1010 DATA $30,$38,$E9,$D0,$90,$0D,$09,$20

1020 DATA $38,$E9,$61,$90,$0B,$C9,$06,$B0

1030 DATA $07,$69,$3A,$E9,$2F,$85,$11,$60

1040 DATA $18,$60 1050 DATA -1

Now we just use a loop like this to load this hex code into a string.

10 RESTORE 1000

20 READ by : REM assume at least one byte

30 DO

40 co$ = co$+CHR$(by)

50 READ by

60 LOOP UNTIL by=-1

The code can now be called by doing ..

140 CALL(SADD(co$))

Note that you must always use the SADD() function to get the address for the CALL as the garbage collection routine may move the string in memory and this is the best way to ensure that the address is always correct.

***Coding for speed***

***Spaces***

Remove spaces from your code. Spaces, while they don't affect the program flow, do take a finite time to skip over. The only space you don't need to worry about is the one between the line number and the code as this is stripped during input parsing and the apparent space is generated by the LIST command output.

E.g. the following ..

10 REM line 10

20 REM line 20

30 REM line 30

.. reads as follows when LISTed

10 REM line 10

20 REM line 20

30 REM line 30

***Removing REM.***

Remove remarks from your code. Remarks like spaces don't do anything, program wise, but take time to skip. Removing remarks, especially from time critical code, can make a big difference.

***Variables.***

Use variables. One place where time is wasted, especially in loops, is repeatedly interpreting numeric values or unchanging functions.

E.g.

.

140 FOR x = 0 to 79

150 POKE $F400+x,ASC(" ") 160 NEXT .

This loop can be improved in a number of ways. First assign a variable the value $F400 and use that. Doing this is faster after only three uses.

E.g.

|  |
| --- |
| 10 a1 = $F400 .  140 FOR x = 0 to 79  150 POKE a1+x,ASC(" ") 160 NEXT  . |

The other way to make this loop faster is to assign the value of the (unchanging) function to a variable, then move the function outside the loop.

E.g.

|  |
| --- |
| 10 a1 = $F400 .  130 sp = ASC(" ")  140 FOR x = 0 to 79  150 POKE a1+x,sp 160 NEXT  . |

Now the ASC(" ") is only evaluated once and the loop is executed faster.

***GOTO and GOSUB***

When EhBASIC encounters a GOTO or GOSUB it has to search through memory for the target line. If the target line follows the command then it searches from the next line, if the target line precedes the command then the search starts from the beginning of program memory. So keeping this distance, in lines, as short as possible will make the program run faster.

One place that this is difficult is in a conditional loop. In calculating points in the Mandelbrot set, for example, code like this is used ..

.

230 INC it

235 tp = mx\*mx-my\*my+x

240 my = 2\*mx\*my+y

245 mx = tp

250 co = (mx\*mx + my\*my)

255 IF (it<128) AND (co<4.0) THEN 230 .

Each time the condition in line 255 is met the interpreter has to search from the start of memory for line 230. While this may not take long if the program is short it can slow longer programs considerably.

This can easily be resolved though by using a DO .. LOOP instead. So our example code becomes..

.

220 DO

230 INC it

235 tp = mx\*mx-my\*my+x

240 my = 2\*mx\*my+y

245 mx = tp

250 co = (mx\*mx + my\*my)

255 LOOP WHILE (it<128) AND (co<4.0) .

This is quicker because the location of the start of the loop, the DO, is placed on the stack and the interpreter doesn't have to search for it.

***Packing them in.***

Another way to speed up time critical code is to place as many commands as possible on each line, this can make a noticeable speed gain.

E.g.

|  |
| --- |
| 10 a1 = $F400 .  130 sp = ASC(" ")  140 FOR x = 0 to 79 : POKE a1+x,sp : NEXT . |

***INC and DEC.***

INCrement and DECrement are quick and clear ways of altering a numeric value by plus or minus one and are faster than using add or subtract.

E.g.

100 INC a

.. is quicker than ..

100 a = a+1

.. and ..

100 INC a,a

.. is still quicker than ..

100 a = a+2

Also combine increments or decrements if you can.

E.g.

100 INC so,d

.. is quicker than ..

100 INC so : INC de

***>> and <<***

Using >> and << can be quicker than using / or \* where integer math and a power of two is involved.

E.g. you want to find the byte that holds the pixel at x,y in a 256 x 32 display

100 ad = y\*32 + INT(x/8) : REM pixel address

.. is done quicker with.

100 ad = y<<5 + x>>3 : REM pixel address

***Coding for space***

Most of the techniques used to improve the speed of a program can also reduce the number of bytes used by that program.

***Spaces.***

Remove spaces from your code. The only space you don't need to worry about is the one between the line number and the code as this is stripped during input parsing and the apparent space is generated by the LIST command output.

***Removing REM.***

Remove remarks from your code. Remarks like spaces don't do anything, removing remarks, can save a lot of space.

***Variables.***

Use variables. Often you will find yourself using the same numeric value again and again. If this value has many digits, such as the value for e (2.718282), then assigning that value at the beginning of the program can start to save space with the third use.

Re-use variables. Every time you assign a new variable a value it takes up six more bytes of the available memory. If you have a variable that is only used as a loop counter then try to use it for temporary values or GET values elsewhere in the program.

***Constants.***

There are two constants defined in EhBASIC, PI and TWOPI. They are the closest floating values to pi and 2\*pi and will save you seven bytes each time you can use them.

***Packing them in.***

Another way to save space is to place as many commands as possible on each line, this will save you five bytes every time you put another command on an existing line compared to using a new line.

***INC and DEC.***

INCrement and DECrement also save space. Either will save you three bytes for each variable INCremented or DECremented.

***Derived functions***

The following functions, while not part of BASIC, can be calculated using the existing BASIC functions.

|  |  |
| --- | --- |
| Secant | SEC(X)=1/COS(X) |
| Cosecant | CSC(X)=1/SIN(X) |
| Cotangent | COT(X)=1/TAN(X) |
| Inverse sine | ARCSIN(X)=ATN(X/SQR(X\*X+1)) |
| Inverse cosine | ARCCOS(X)=-ATN(X/SQR(X\*X+1))+PI/2 |
| Inverse secant | ARCSEC(X)=ATN(SQR(X\*X-1))+(SGN(X)-1)\*PI/2 |
| Inverse cosecant | ARCCSC(X)=ATN(1/SQR(X\*X-1))+(SGN(X)-  1)\*PI/2 |
| Inverse cotangent | ARCCOT(X)=-ATN(X)+PI/2 |
| Hyperbolic sine | SINH(X)=(EXP(X)-EXP(-X))/2 |
| Hyperbolic cosine | COSH(X)=(EXP(X)+EXP(-X))/2 |
| Hyperbolic tangent | TANH(X)=-EXP(-X)/(EXP(X)+EXP(-X))\*2+1 |
| Hyperbolic secant | SECH(X)=2/(EXP(X)+EXP(-X)) |
| Hyperbolic cosecant | CSCH(X)=2/(EXP(X)-EXP(-X)) |
| Hyperbolic cotangent | COTH(X)=EXP(-X)/(EXP(X)-EXP(-X))\*2+1 |
| Inverse hyperbolic sine | ARCSINH(X)=LOG(X+SQR(X\*X+1)) |
| Inverse hyperbolic cosine | ARCCOSH(X)=LOG(X+SQR(X\*X-1)) |
| Inverse hyperbolic tangent | ARCTANH(X)=LOG((1+X)/(X))/2 |
| Inverse hyperbolic secant | ARCSECH(X)=LOG((SQR(X\*X+1)+1)/X) |
| Inverse hyperbolic cosecant | ARCCSCH(X)=LOG((SGN(X)\*SQR(X\*X+1)+1)/X) |
| Inverse hyperbolic cotangent | ARCCOTH(X)=LOG((X+1)/(X-1))/2 |

## Enhanced BASIC, extending CALL

***Introduction.***

CALL <address> calls a machine code routine at location address. While this in itself is useful it can be extended by adding parameters to the CALL and parsing them from within the routine.

This technique can also be used to pass extra parameters to the USR() function.

***How to.***

First you need to define the parameters for your CALL. This example is for an imaginary bitmapped graphic device.

**CALL PLOT,x,y** Set the pixel at x,y

PLOT routine address

x x axis value, range 0 to 255

y y axis value, range 0 to 64

This will then be the form that the call will always take.

Now you need to write the code.

|  |
| --- |
| .include BASIC.DIS ; include the BASIC labels file. this allows you  ; easy access to the internal routines you need  ; to parse the command stream and access some of  ; the internals of BASIC. It is usually output ; by the assembler as part of the listing or as a ; separate, optional, file.    ; for now we'll put this in the spare RAM @ $F400    \*= $F400    PLOT  JSR LAB\_SCGB ; scan for "," and get byte  STX PLOT\_XBYT ; save plot x  JSR LAB\_SCGB ; scan for "," and get byte  CPX #$40 ; compare with max+1  BCS PLOT\_FCER ; if 64d or greater do function call error    STX PLOT\_YBYT ; save plot y    ; now would be your code to perform the plot command  ;.  ;.  ;.  ;.  ;.    RTS ; return to BASIC    ; does BASIC function call error  PLOT\_FCER  JMP LAB\_FCER ; do function call error, then warm start    ; now we just need the variable storage    PLOT\_XBYT  .byte $00 ; set default    PLOT\_YBYT  .byte $00 ; set default    END |

Finally you need to set the value of PLOT in your BASIC program and use that to call it.

E.g.

.

10 PLOT = $F400

.

.

145 CALL PLOT,25,14 : REM set pixel .

## Enhanced BASIC, using USR()

***Introduction.***

USR(<expression[$]>) calls the machine code function pointed to by the user jump vector after evaluating <expression[$]> and placing the result in the first floating accumulator. Once the user function exits, via an RTS, the value in the floating accumulator is passed back to EhBASIC.

Either a numeric value or a string can be passed, and either type can be returned depending on the setting of the data type flag at the end of the user code and the return point (see code examples for details).

It can also be extended by adding parameters to USR() and parsing them from within the routine in the same way that CALL can be extended, just remember to get the value from FAC1 first.

***How to - numeric source, numeric result.***

First you need to write the code.

|  |  |  |
| --- | --- | --- |
| ; this code demonstrates the use of USR() to quickly calculate the square of a  ; byte value. Compare this with doing SQ=A\*A or even SQ=A^2.    .include BASIC.DIS ; include the BASIC labels file. this allows  ; you easy access to the internal routines you  ; need to parse the command stream and access  ; some of the internals of BASIC. It is usually ; output by the assembler as part of the listing ; or as a separate, optional, file.    ; for now we'll put this in the spare RAM @ $F400    \*= $F400    Square  JSR LAB\_EVBY ; evaluate byte expression, result in X and FAC1\_3  LDA #$00 ; clear A  STA FAC1\_2 ; clear square low byte (use FAC1 as the workspace)  ; (no need to clear the high byte, it gets shifted out)  TXA ; copy byte to A  LDX #$08 ; set bit count  Nextr2bit  ASL FAC1\_2 ; low byte \*2  ROL FAC1\_1 ; high byte \*2+carry from low | | |
| ASL | A | ; shift byte |
| BCC | NoSqadd | ; don't do add if C = 0 |
| TAY |  | ; save A |
| CLC |  | ; clear carry for add |
| LDA | FAC1\_3 | ; get number |
| ADC | FAC1\_2 | ; add number^2 low byte |
| STA | FAC1\_2 | ; save number^2 low byte |
| LDA | #$00 | ; clear A |
| ADC | FAC1\_1 | ; add number^2 high byte |
| STA | FAC1\_1 | ; save number^2 high byte |
| TYA |  | ; get A back |
| NoSqadd  DEX |  | ; decrement bit count |
| BNE | Nextr2bit | ; go do next bit |
| LDX | #$90 | ; set exponent=2^16 (integer) |
| SEC |  | ; set carry for positive result |
| JMP | LAB\_STFA | ; set exp=X, clearFAC1 mantissa3, normalise & return |

Now you need to set up the address for your function. This is done by DOKEing an address into the USR() vector e.g.

|  |  |
| --- | --- |
| DOKE $0B,$F400 | ; set the user function address to addr  ; $0B - user function vector address  ; $F400 - routine address |

Finally you need to set the vector in your BASIC program and use that to call the function

.

10 DOKE $0B,$F400

.

.

.

145 SQ=USR(A) .

***How to - numeric source, string result.***

AS before, first you need to write the code.

; this code demonstrates the use of USR() to generate a string of # characters.

; the length of the required string is the parameter passed.

.include BASIC.DIS ; include the BASIC labels file. this allows

; you easy access to the internal routines you

; need to parse the command stream and access

; some of the internals of BASIC. It is usually ; output by the assembler as part of the listing ; or as a separate, optional, file.

; for now we'll put this in the spare RAM @ $F400

\*= $F400

STRING

JSR LAB\_EVBY ; evaluate byte expression, result in X and FAC1\_3

TXA ; string is byte length

|  |  |  |
| --- | --- | --- |
| BEQ | NUL\_STRN | ; branch if null string |
| JSR | LAB\_MSSP | ; make string space A bytes long A=$AC=length,  ; X=$AD=Sutill=ptr low byte,  ; Y=$AE=Sutilh=ptr high byte |
| LDA | #"#" | ; set character |
| LDY | FAC1\_3 | ; get length |
| SAV\_HASH  DEY |  | ; decrement bytes to do |
| STA | (str\_pl),Y | ; save byte in string |
| BNE | SAV\_HASH | ; loop if not all done |
| NUL\_STRN  PLA |  | ; dump return address (return via get value |
| PLA |  | ; from line, this skips the type checking and  ; so allows a string result to be returned) |
| JMP | LAB\_RTST | ; check for space on descriptor stack then put ; string address and length on descriptor stack  ; & update stack pointers |

Now you need to set up the address for your function. This is done by DOKEing an address into the USR() vector e.g.

|  |  |
| --- | --- |
| DOKE $0B,$F400 | ; set the user function address to addr  ; $0B - user function vector address  ; $F400 - routine address |

Finally you need to set the vector in your BASIC program and use that to call the function

.

10 DOKE $0B,$F400

.

.

.

145 HA$=USR(A) .

***How to - string source, numeric result.***

AS before, first you need to write the code.

; this code demonstrates the use of USR() to test a string of characters.

; if all the string is alpha -1 is returned, else 0 is returned.

.include BASIC.DIS ; include the BASIC labels file. this allows

; you easy access to the internal routines you

; need to parse the command stream and access

; some of the internals of BASIC. It is usually ; output by the assembler as part of the listing ; or as a separate, optional, file.

; for now we'll put this in the spare RAM @ $F400

\*= $F400

ALPHA

JSR LAB\_EVST ; evaluate string

|  |  |  |
| --- | --- | --- |
| TAX |  | ; copy length to X |
| BEQ | NOT\_ALPH | ; branch if null string |
| LDY | #$00 | ; clear index |
| ALP\_LOOP  LDA | (ut1\_pl),Y | ; get byte from string |
| JSR | LAB\_CASC | ; is character "a" to "z" (or "A" to "Z") |
| BCC | NOT\_ALPH | ; branch if not alpha |
| INY |  | ; increment index |
| DEX |  | ; decrement count |
| BNE | ALP\_LOOP | ; loop if not all done |
| LDA | #$FF | ; set for -1 |
| BNE | IS\_ALPHA | ; branch always |
| NOT\_ALPH  LDA | #$00 | ; set for 0 |
| IS\_ALPHA  TAY |  | ; copy byte |
| LDX | #$00 | ; clear byte |
| STX | Dtypef | ; clear data type flag, $00=numeric |
| JMP | LAB\_AYFC | ; save & convert integer AY to FAC1 & return |

Now you need to set up the address for your function. This is done by DOKEing an address into the USR() vector e.g.

|  |  |
| --- | --- |
| DOKE $0B,$F400 | ; set the user function address to addr  ; $0B - user function vector address  ; $F400 - routine address |

Finally you need to set the vector in your BASIC program and use that to call the function

.

10 DOKE $0B,$F400

.

.

.

145 AL=USR(A$) .

***How to - string source, string result.***

AS before, first you need to write the code.

; this code demonstrates the use of USR() invert the case of a string of

; characters. only alpha characters will be affected.

.include BASIC.DIS ; include the BASIC labels file. this allows

; you easy access to the internal routines you

; need to parse the command stream and access

; some of the internals of BASIC. It is usually ; output by the assembler as part of the listing ; or as a separate, optional, file.

; for now we'll put this in the spare RAM @ $F400

\*= $F400

|  |  |  |
| --- | --- | --- |
| ALPHA  JSR | LAB\_EVST | ; evaluate string |
| STA | str\_ln | ; set string length |
| STX | str\_pl | ; set string pointer low byte |
| STY | str\_ph | ; set string pointer high byte |
| TAX |  | ; copy length to X |
| BEQ | NO\_STRNG | ; branch if null string |
| LDY | #$00 | ; clear index |
| ALP\_LOOP  LDA | (ut1\_pl),Y | ; get byte from string |
| JSR | LAB\_CASC | ; is character "a" to "z" (or "A" to "Z") |
| BCC | NOT\_ALPH | ; branch if not alpha |
| EOR | #$20 | ; toggle case |
| STA | (ut1\_pl),Y | ; save byte back to string |
| NOT\_ALPH  INY |  | ; increment index |
| DEX |  | ; decrement count |
| BNE | ALP\_LOOP | ; loop if not all done |
| NO\_STRNG  PLA |  | ; dump return address (return via get value |
| PLA |  | ; from line, this skips the type checking and  ; so allows a string result to be returned) |
| JMP | LAB\_RTST | ; check for space on descriptor stack then put  ; string address and length on descriptor stack  ; & update stack pointers |

Now you need to set up the address for your function. This is done by DOKEing an address into the USR() vector e.g.

|  |  |
| --- | --- |
| DOKE $0B,$F400 | ; set the user function address to addr  ; $0B - user function vector address  ; $F400 - routine address |

Finally you need to set the vector in your BASIC program and use that to call the function

.

10 DOKE $0B,$F400

.

.

.

145 A$=USR(A$) .

## Enhanced BASIC internals

***Floating point numbers.***

Floating point numbers are stored in memory in four bytes. The format of the numbers is as follows.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Exponent | S | Mantissa 1 | Mantissa 2 | Mantissa 3 |

#### Exponent

This is the power of two to which the mantissa is to be raised. This number is biased to +$80 i.e. 2^0 is represented by $80, 2^1 by $81 etc. Zero is a special case and is used to represent the value zero for the whole of the number.

**S**

Sign bit. This bit (b7 of mantissa 1) is one if the number is negative.

#### Mantissa 1/2/3

This is the 24 bit mantissa of the number and is normalised to make the highest bit (b7 of mantissa 1) always one. So the absolute value of the mantissa varies between 0.5 and 0.9999999403954 . As we know that the highest bit is always one it is replaced by the sign bit in memory.

***Example.***

$82,$49,$0F,$DB = +3.14159274 nearest floating equivalent to pi

| || | |

| |\--+---+- = 0.785398185 absolute value of mantissa | |

| \--------- = + b7 of mantissa 1 is zero

|

\------------- = x 2^2 = 4 mantissa to be multiplied by 4

Values represented in this way range between + and - 1.70141173x10^38

***BASIC program memory use.***

A BASIC program is stored in memory from Ram\_base upwards. It's format is ..

$00 Start of program marker byte

.. then each BASIC program line which is stored as ..

start of next line pointer low byte start of next line pointer high byte

line number low byte line number high byte code byte(s)

$00 End of line marker byte

.. and finally ..

$00 End of program marker byte 1 $00 End of program marker byte 2

If there is no program in memory only the start and end marker bytes are present.

***BASIC variables memory use.***

After the program come the variables and function references, all six bytes long, which are stored as ..

1st character of variable or function name (+$80 if FN name)

2nd character of variable or function name (+$80 if string)

.. then for each type ..

**Numeric String Function**

Exponent String length BASIC execute pointer low byte

Sign (bit 7) + mantissa 1 String pointer low byte BASIC execute pointer high byte

Mantissa 2 String pointer high byte Function variable name 1st character

Mantissa 3 $00 Function variable name 2nd character

After the variables come the arrays, which are stored as ..

1st character of variable name

2nd character of variable name (+$80 if string) array size in bytes low byte (size includes this header) array size in bytes high byte number of dimensions

[dimension 3 size high byte] (lowest element is zero)

[dimension 3 size low byte]

[dimension 2 size high byte] (lowest element is zero)

[dimension 2 size low byte]

dimension 1 size high byte (lowest element is zero) dimension 1 size low byte

.. and then each element ..

**Numeric String**

Exponent String length

Sign (bit 7) + mantissa 1 String pointer low byte

Mantissa 2 String pointer high byte

Mantissa 3 $00

The elements of every array are stored in the order ..

index1 [0-n], index2 [0-n], index3 [0-n]

i.e. element (1,2,3) in an array of (3,4,5) would be the ..

1 + 1 + 2\*(3+1) + 3\*(3+1)\*(4+1) = 70th element

*(As array dimensions range from 0 to n element n will always be the (n+1)th element in memory.)*

***String placement in memory.***

Strings are generally stored from the top of available RAM, Ram\_top, working down, however if the interpreter encounters a line such as ..

100 A$ = "This is a string"

.. then the high/low pointer in the A$ descriptor will point to the string in program memory and will not make a copy of the string in the string memory.

***String descriptors in BASIC.***

A string descriptor is a three byte table that describes a string, it is of the format ..

base = string length base+1 = string pointer low byte base+2 = string pointer high byte

***Stack use in BASIC.***

GOSUB and DO both push on the stack ..

BASIC execute pointer high byte BASIC execute pointer low byte

current line high byte

current line low byte

command token (TK\_GOSUB or TK\_DO)

FOR pushes on the stack ..

BASIC execute pointer low byte

BASIC execute pointer high byte

FOR line high byte

FOR line low byte

TO value mantissa3

TO value mantissa2

TO value mantissa1

TO value exponent

STEP sign

STEP value mantissa3

STEP value mantissa2

STEP value mantissa1 STEP value exponent var pointer for FOR/NEXT high byte var pointer for FOR/NEXT low byte token for FOR (TK\_FOR)

## Enhanced BASIC, useful routines

***Introduction.***

There are many subroutines within BASIC that can be useful if you wish to use your own assembly routines with it. Here are some of them with a brief description of their function. For full details see the source code.

Note that most, if not all, of these routines need EhBASIC to be initialised before they will work properly and can not be used in isolation from EhBASIC.

***The routines.***

#### LAB\_IGBY

BASIC increment and get byte routine. gets the next byte from the BASIC command stream. If the byte is a numeric character then the carry flag will be set, if the byte is a termination byte, either null or a statement separator, then the zero flag will be set. Spaces in the command stream will automatically be ignored.

#### LAB\_GBYT

BASIC get byte routine. Gets the current byte from the BASIC command stream but does not change the pointer. Otherwise the same as above.

**LAB\_COLD**

Performs a cold start. BASIC is reset and all BASIC memory is cleared.

**LAB\_WARM**

Performs a warm start. Execution is stopped and BASIC returns to immediate mode.

**LAB\_OMER**

Do "Out of memory" error, then warm start. The same as error $0C below.

#### LAB\_XERR

With X set, do error #X, then warm start.

|  |  |  |  |
| --- | --- | --- | --- |
| **X** | **Error** | **X** | **Error** |
| $00 | NEXT without FOR | $02 | syntax |
| $04 | RETURN without GOSUB | $06 | out of data |
| $08 | function call | $0A | overflow |
| $0C | out of memory | $0E | undefined statement |
| $10 | array bounds | $12 | double dimension array |
| $14 | divide by 0 | $16 | illegal direct |
| $18 | type mismatch | $1A | long string |
| $1C | string too complex | $1E | continue error |
| $20 | undefined function | $22 | LOOP without DO |

#### LAB\_INLN

Print "? " and get BASIC input. Returns XY (low/high) as a pointer to the start of the input line. The input is null terminated.

#### LAB\_SSLN

Search Basic for a line, the line number required is held in the temporary integer, from start of program memory. Returns carry set and a pointer to the line in Baslnl/Baslnh if found, if not it returns carry and a pointer to the next numbered line in Baslnl/Baslnh.

#### LAB\_SHLN

Search Basic for temporary integer line number from AX. Same as above but starts the search from AX (low/high).

**LAB\_SNBS**

Scan for next BASIC statement (: or [EOL]). Returns Y as index to : or [EOL] from (Bpntrl).

**LAB\_SNBL**

Scan for next BASIC line. Same as above but only returns on [EOL].

**LAB\_REM**

Perform REM, skip (rest of) line.

**LAB\_GFPN**

Get fixed-point number into temporary integer.

**LAB\_CRLF**

Print [CR]/[LF] to output device.

**LAB\_PRNA**

Print character in A to output device.

#### LAB\_GVAR

Get variable address. Returns a pointer to the variable in Lvarpl/h and sets the data type flag, $FF=string, $00=numeric.

#### LAB\_EVNM

Evaluates an expression and checks the result is numeric, if not it does a type mismatch. The result of the expression is returned in FAC1.

**LAB\_CTNM**

Check if source is numeric, else do type mismatch.

**LAB\_CTST**

Check if source is string, else do type mismatch.

**LAB\_CKTM**

Type match check, set carry for string, clear carry for numeric.

**LAB\_EVEX**

Evaluate expression.

**LAB\_GVAL**

Get numeric value from line. Returns the result in FAC1.

**LAB\_SCCA**

Scan for the byte in A as the next byte. If so return here, else do syntax error then warm start.

**LAB\_SNER**

Do syntax error, then warm start.

**LAB\_CASC**

Check byte is alpha ("A" to "Z" or "a" to "z"), return carry clear if so.

**LAB\_EVIN**

Evaluate integer expression. Return integer in FAC1\_3/FAC1\_2 (low/high).

**LAB\_EVPI**

Evaluate positive integer expression.

**LAB\_EVIR**

Evaluate integer expression, check is in range -32786 to 32767

**LAB\_FCER**

Do function call error, then warm start.

#### LAB\_CKRN

Check that the interpreter is not in immediate mode. If not then return, if so do illegal direct error.

**LAB\_GARB**

Perform garbage collection routine.

**LAB\_EVST**

Evaluate string.

**LAB\_ESGL**

Evaluate string, return string length in Y.

**LAB\_SGBY**

Scan and get byte parameter, return the byte in X.

#### LAB\_GTBY

Get byte parameter and ensure numeric type, else do type mismatch error. Return the byte in X.

**LAB\_EVBY**

Evaluate byte expression, return the byte in X.

#### LAB\_GADB

Get two parameters as in POKE or WAIT. Return the byte (second parameter) in X and the integer (first parameter) in the temporary integer pair, Itempl/Itemph.

**LAB\_SCGB**

Scan for "," and get byte, else do Syntax error then warm start. Return the byte in X.

#### LAB\_F2FX

New convert float to fixed routine. accepts any value that fits into 24 bits, positive or negative and converts it into a right truncated integer in the temporary integer pair, Itempl/Itemph.

**LAB\_UFAC**

Unpack the four bytes starting (AY) into FAC1 as a floating point number.

**LAB\_PFAC**

Pack the floating point number in FAC1 into the current variable (Lvarpl).

#### LAB\_STFA

Stores a 16 bit number in FAC1. Set X to the exponent required (usually $90) and the carry set for positive numbers and clear for negative numbers. The routine will clear FAC1 mantissa3 and then normalise it.

#### LAB\_AYFC

Save integer AY (A = high byte, Y = low byte) in FAC1 and convert to float. The result will be -32768 to +32767.

#### LAB\_MSSP

Make string space A bytes long. This returns the following. str\_ln = A = string length str\_pl = Sutill = string pointer low byte str\_ph = Sutilh = string pointer high byte

#### LAB\_RTST

Return string. Takes the string described instr\_ln, str\_pl and str\_ph and puts it on the string stack. This is how you return a string to BASIC.

## WE816 Hardware Reference

***Using Supermon***

The WE816 computer utilizes BCS Technology’s (http://sbc.bcstechnology.net/) Supermon 816 monitor program for its machine language monitor. To access Supermon, type ‘MONITOR’ from BASIC. You will be greeted by Supermon’s welcome screen.

\_\_ \_\_\_\_\_ \_\_\_ \_\_ \_\_

/ /| \_\_\_\_|/ \_ \/\_ | / /

/ /\_| |\_\_ | (\_) || |/ /\_

| \_ \\_\_\_ \ > \_ < | | \_ \

| (\_) |\_\_) | (\_) || | (\_) |

\\_\_\_/\_\_\_\_/ \\_\_\_/ |\_|\\_\_\_/

65c816 BIOS (NATIVE MODE)

v0.55 4/9/2021 - D.WERNER

-------------------------------------

PB PC NVmxDIZC .C .X .Y SP

F2 4F58 00110000 0000 0000 0000 7FFF

DP DB

0000 00

.

From the ‘.’ Prompt, you can enter any of Supermon’s commands.

* A Assemble code
* C Compare memory regions
* D Disassemble code
* F Fill memory region (cannot span banks)
* G Execute code (stops at BRK)
* H Search (hunt) memory
* J Execute code as a subroutine (stops at BRK or RTS)
* L Load Motorola S28-records
* M Dump & display memory range
* R Dump & display 65C816 registers
* T Copy (transfer) memory region
* > Modify up to 32 bytes of memory
* ; Modify 65C816 registers

Supermon 816 accepts binary (%), octal (@), decimal (+) and hexadecimal ($) as input for numeric parameters. Additionally, the H and > operations accept an ASCII string in place of numeric values by preceding the string with ', e.g.:

h 042000 042FFF 'BCS Technology Limited

If no radix symbol is entered hex is assumed.

Numeric conversion is also available. For example, typing:

+1234567 [CR]

at the monitor's prompt will display:

$12D687

+1234567

@04553207

%100101101011010000111

In the above example, [CR] means the console keyboard's return or enter key.

All numeric values are internally processed as 32 bit unsigned integers. Addresses may be entered as 8, 16 or 24 bit values. During instruction assembly immediate mode operands may be forced to 16 bits by preceding the operand with an exclamation point if the instruction can accept a 16 bit operand, e.g.:

a 1f2000 lda !#4

The above will assemble as:

A 1F2000 A9 04 00 LDA #$0004

Entering:

a 1f2000 ldx !#+157

will assemble as:

A 1F2000 A2 9D 00 LDX #$009D

Absent the ! in the operand field, the above would have been assembled as:

A 1F2000 A2 9D LDX #$9D

If an immediate mode operand is greater than $FF, assembly of a 16 bit operand is implied.

***Redirecting Console to the Serial Port***

The WE816 computer defaults console input/output to it’s built in keyboard and display, however it is possible to change the console display from internal to the serial port. Location $0341 in memory tells the computer which to use. If $341 contains a $01, the system will use the internal console, and value $00 designates the serial port.

To change the console using Supermon 816, enter:

>0341 00[ENTER]

And the system will change to the serial console. Entering:

>0341 01[ENTER]

Will change back to the internal video and keyboard.

***Returning to BASIC***

To return to BASIC from Supermon 816, just execute the “G” command with the address of the BASIC startup code.

G FF1000[ENTER]

## Screen Font

The following is the screen font for the WE816. Qr code

Description automatically generated

## Musical Note to “Frequencies”

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **value** | **Produced freq** | **note** | **Note freq** | **variance** | **out of tune** |
| 14 | 7990.313 | B8 | 7902.13 | -88.1825 | 1% |
| 15 | 7457.625 | A8 | 7040 | -417.625 | 6% |
| 16 | 6991.523 | G#8/Ab8 | 6644.88 | -346.643 | 5% |
| 17 | 6580.257 | G8 | 6271.93 | -308.327 | 5% |
| 18 | 6214.688 | F#8/Gb8 | 5919.91 | -294.778 | 5% |
| 20 | 5593.219 | F8 | 5587.65 | -5.56875 | 0% |
| 21 | 5326.875 | E8 | 5274.04 | -52.835 | 1% |
| 22 | 5084.744 | D#8/Eb8 | 4978.03 | -106.714 | 2% |
| 23 | 4863.668 | D8 | 4698.63 | -165.038 | 3% |
| 25 | 4474.575 | C#8/Db8 | 4434.92 | -39.655 | 1% |
| 26 | 4302.476 | C8 | 4186.01 | -116.466 | 3% |
| 28 | 3995.156 | B7 | 3951.07 | -44.0862 | 1% |
| 29 | 3857.392 | A#7/Bb7 | 3729.31 | -128.082 | 3% |
| 31 | 3608.528 | A7 | 3520 | -88.5282 | 2% |
| 33 | 3389.83 | G#7/Ab7 | 3322.44 | -67.3895 | 2% |
| 37 | 3023.361 | F#7/Gb7 | 2959.96 | -63.4015 | 2% |
| 42 | 2663.438 | E7 | 2637.02 | -26.4175 | 1% |
| 44 | 2542.372 | D#7/Eb7 | 2489.02 | -53.3522 | 2% |
| 47 | 2380.093 | D7 | 2349.32 | -30.7731 | 1% |
| 50 | 2237.288 | C#7/Db7 | 2217.46 | -19.8275 | 1% |
| 53 | 2110.649 | C7 | 2093 | -17.6486 | 1% |
| 56 | 1997.578 | B6 | 1975.53 | -22.0481 | 1% |
| 59 | 1896.006 | A#6/Bb6 | 1864.66 | -31.3464 | 2% |
| 63 | 1775.625 | A6 | 1760 | -15.625 | 1% |
| 67 | 1669.618 | G#6/Ab6 | 1661.22 | -8.39754 | 1% |
| 71 | 1575.555 | G6 | 1567.98 | -7.57458 | 0% |
| 75 | 1491.525 | F#6/Gb6 | 1479.98 | -11.545 | 1% |
| 84 | 1331.719 | E6 | 1318.51 | -13.2088 | 1% |
| 89 | 1256.903 | D#6/Eb6 | 1244.51 | -12.3931 | 1% |
| 95 | 1177.52 | D6 | 1174.66 | -2.85974 | 0% |
| 100 | 1118.644 | C#6/Db6 | 1108.73 | -9.91375 | 1% |
| 106 | 1055.324 | C6 | 1046.5 | -8.82429 | 1% |
| 113 | 989.9502 | B5 | 987.77 | -2.18022 | 0% |
| 119 | 940.0368 | A#5/Bb5 | 932.33 | -7.70676 | 1% |
| 127 | 880.8219 | A5 | 880 | -0.82185 | 0% |
| 134 | 834.8088 | G#5/Ab5 | 830.61 | -4.19877 | 1% |
| 142 | 787.7773 | G5 | 783.99 | -3.78729 | 0% |
| 151 | 740.8237 | F#5/Gb5 | 739.99 | -0.83368 | 0% |
| 160 | 699.1523 | F5 | 698.46 | -0.69234 | 0% |
| 169 | 661.9194 | E5 | 659.25 | -2.66938 | 0% |
| 179 | 624.9406 | D#5/Eb5 | 622.25 | -2.69064 | 0% |
| 190 | 588.7599 | D5 | 587.33 | -1.42987 | 0% |
| 201 | 556.5392 | C#5/Db5 | 554.37 | -2.16918 | 0% |
| 213 | 525.1849 | C5 | 523.25 | -1.93486 | 0% |
| 226 | 494.9751 | B4 | 493.88 | -1.09511 | 0% |
| 239 | 468.0518 | A#4/Bb4 | 466.16 | -1.89178 | 0% |
| 254 | 440.4109 | A4 | 440 | -0.41093 | 0% |
| 269 | 415.8527 | G#4/Ab4 | 415.3 | -0.5527 | 0% |
| 285 | 392.5066 | G4 | 392 | -0.50658 | 0% |
| 302 | 370.4118 | F#4/Gb4 | 369.99 | -0.42184 | 0% |
| 339 | 329.9834 | E4 | 329.63 | -0.35341 | 0% |
| 359 | 311.5999 | D#4/Eb4 | 311.13 | -0.46993 | 0% |
| 380 | 294.3799 | D4 | 293.66 | -0.71993 | 0% |
| 403 | 277.5791 | C#4/Db4 | 277.18 | -0.39909 | 0% |
| 427 | 261.9775 | C4 | 261.63 | -0.34746 | 0% |
| 453 | 246.9412 | B3 | 246.94 | -0.00123 | 0% |
| 479 | 233.5373 | A#3/Bb3 | 233.08 | -0.45732 | 0% |
| 508 | 220.2055 | A3 | 220 | -0.20546 | 0% |
| 570 | 196.2533 | G3 | 196 | -0.25329 | 0% |
| 604 | 185.2059 | F#3/Gb3 | 185 | -0.20592 | 0% |
| 640 | 174.7881 | F3 | 174.61 | -0.17809 | 0% |
| 678 | 164.9917 | E3 | 164.81 | -0.1817 | 0% |
| 719 | 155.5833 | D#3/Eb3 | 155.56 | -0.02328 | 0% |
| 761 | 146.9966 | D3 | 146.83 | -0.16655 | 0% |
| 807 | 138.6176 | C#3/Db3 | 138.59 | -0.02757 | 0% |
| 855 | 130.8355 | C3 | 130.81 | -0.02553 | 0% |
| 906 | 123.4706 | B2 | 123.47 | -0.00061 | 0% |
| 959 | 116.6469 | A#2/Bb2 | 116.54 | -0.1069 | 0% |
| 1016 | 110.1027 | A2 | 110 | -0.10273 | 0% |
| 1077 | 103.8666 | G#2/Ab2 | 103.83 | -0.03664 | 0% |
| 1141 | 98.04064 | G2 | 98 | -0.04064 | 0% |
| 1209 | 92.52636 | F#2/Gb2 | 92.5 | -0.02636 | 0% |
| 1281 | 87.32582 | F2 | 87.31 | -0.01582 | 0% |
| 1357 | 82.43506 | E2 | 82.41 | -0.02506 | 0% |
| 1438 | 77.79164 | D#2/Eb2 | 77.78 | -0.01164 | 0% |
| 1523 | 73.45002 | D2 | 73.42 | -0.03002 | 0% |
| 1614 | 69.30878 | C#2/Db2 | 69.3 | -0.00878 | 0% |
| 1710 | 65.41776 | C2 | 65.41 | -0.00776 | 0% |
| 1811 | 61.7694 | B1 | 61.74 | -0.0294 | 0% |
| 1919 | 58.29306 | A#1/Bb1 | 58.27 | -0.02306 | 0% |
| 2033 | 55.02429 | A1 | 55 | -0.02429 | 0% |
| 2154 | 51.93332 | G#1/Ab1 | 51.91 | -0.02332 | 0% |
| 2282 | 49.02032 | G1 | 49 | -0.02032 | 0% |
| 2418 | 46.26318 | F#1/Gb1 | 46.25 | -0.01318 | 0% |
| 2562 | 43.66291 | F1 | 43.65 | -0.01291 | 0% |
| 2715 | 41.20235 | E1 | 41.2 | -0.00235 | 0% |
| 2876 | 38.89582 | D#1/Eb1 | 38.89 | -0.00582 | 0% |
| 3047 | 36.71296 | D1 | 36.71 | -0.00296 | 0% |
| 3228 | 34.65439 | C#1/Db1 | 34.65 | -0.00439 | 0% |
| 3420 | 32.70888 | C1 | 32.7 | -0.00888 | 0% |
| 3623 | 30.87617 | B0 | 30.87 | -0.00617 | 0% |
| 3838 | 29.14653 | A#0/Bb0 | 29.14 | -0.00653 | 0% |
| 4067 | 27.50538 | A0 | 27.5 | -0.00538 | 0% |

## 

## Memory Map

|  |  |  |  |
| --- | --- | --- | --- |
| **Address (Decimal)** | **Address (Hex)** | **Label** | **Comment** |
| 0 | 00:0000 | LAB\_WARM | BASIC warm start entry point |
| 1 | 00:0001 | Wrmjpl | BASIC warm start vector jump low byte |
| 2 | 00:0002 | Wrmjph | BASIC warm start vector jump high byte |
| 4 | 00:0004 | TMPFLG | BASIC Temp area |
| 6 | 00:0006 | VIDEOMODE | BASIC Current Video Mode |
| 7 | 00:0007 | LOCALWORK | word (2 bytes) |
| 10 | 00:000A | Usrjmp | USR function JMP address |
| 11 | 00:000B | Usrjpl | USR function JMP vector low byte |
| 12 | 00:000C | Usrjph | USR function JMP vector high byte |
| 13 | 00:000D | Nullct | nulls output after each line |
| 14 | 00:000E | TPos | BASIC terminal position byte |
| 15 | 00:000F | TWidth | BASIC terminal width byte |
| 16 | 00:0010 | Iclim | input column limit |
| 17 | 00:0011 | Itempl | temporary integer low byte |
| 18 | 00:0012 | Itemph | temporary integer high byte |
| 17 | 00:0011 | nums\_1 | number to bin/hex string convert MSB |
| 18 | 00:0012 | nums\_2 | number to bin/hex string convert |
| 19 | 00:0013 | nums\_3 | number to bin/hex string convert LSB |
| 91 | 00:005B | Srchc | search character |
| 91 | 00:005B | Temp3 | temp byte used in number routines |
| 92 | 00:005C | Scnquo | scan-between-quotes flag |
| 92 | 00:005C | Asrch | alt search character |
| 91 | 00:005B | XOAw\_l | eXclusive OR, OR and AND word low byte |
| 92 | 00:005C | XOAw\_h | eXclusive OR, OR and AND word high byte |
| 93 | 00:005D | Ibptr | input buffer pointer |
| 93 | 00:005D | Dimcnt | # of dimensions |
| 93 | 00:005D | Tindx | token index |
| 94 | 00:005E | Defdim | default DIM flag |
| 95 | 00:005F | Dtypef | data type flag, $FF=string, $00=numeric |
| 96 | 00:0060 | Oquote | open quote flag (b7) (Flag: DATA scan |
| 96 | 00:0060 | Gclctd | garbage collected flag |
| 97 | 00:0061 | Sufnxf | subscript/FNX flag, 1xxx xxx = FN(0xxx xxx) |
| 98 | 00:0062 | Imode | input mode flag, $00=INPUT, $80=READ |
| 99 | 00:0063 | Cflag | comparison evaluation flag |
| 100 | 00:0064 | TabSiz | TAB step size (was input flag) |
| 101 | 00:0065 | next\_s | next descriptor stack address |
|  |  |  | these two bytes form a word pointer to the item |
|  |  |  | currently on top of the descriptor stack |
| 102 | 00:0066 | last\_sl | last descriptor stack address low byte |
| 103 | 00:0067 | last\_sh | last descriptor stack address high byte (always $00) |
| 104 | 00:0068 | des\_sk | descriptor stack start address (temp strings) |
| 112 | 00:0070 |  | End of descriptor stack |
| 113 | 00:0071 | ut1\_pl | utility pointer 1 low byte |
| 114 | 00:0072 | ut1\_ph | utility pointer 1 high byte |
| 115 | 00:0073 | ut2\_pl | utility pointer 2 low byte |
| 116 | 00:0074 | ut2\_ph | utility pointer 2 high byte |
| 113 | 00:0071 | Temp\_2 | temp byte for block move |
| 117 | 00:0075 | FACt\_1 | FAC temp mantissa1 |
| 118 | 00:0076 | FACt\_2 | FAC temp mantissa2 |
| 119 | 00:0077 | FACt\_3 | FAC temp mantissa3 |
| 118 | 00:0076 | dims\_l | array dimension size low byte |
| 119 | 00:0077 | dims\_h | array dimension size high byte |
| 120 | 00:0078 | TempB | temp page 0 byte |
| 121 | 00:0079 | Smeml | start of mem low byte (Start-of-Basic) |
| 122 | 00:007A | Smemh | start of mem high byte (Start-of-Basic) |
| 123 | 00:007B | Svarl | start of vars low byte (Start-of-Variables) |
| 124 | 00:007C | Svarh | start of vars high byte (Start-of-Variables) |
| 125 | 00:007D | Sarryl | var mem end low byte (Start-of-Arrays) |
| 126 | 00:007E | Sarryh | var mem end high byte (Start-of-Arrays) |
| 127 | 00:007F | Earryl | array mem end low byte (End-of-Arrays) |
| 128 | 00:0080 | Earryh | array mem end high byte (End-of-Arrays) |
| 129 | 00:0081 | Sstorl | string storage low byte (String storage (moving down)) |
| 130 | 00:0082 | Sstorh | string storage high byte (String storage (moving down)) |
| 131 | 00:0083 | Sutill | string utility ptr low byte |
| 132 | 00:0084 | Sutilh | string utility ptr high byte |
| 133 | 00:0085 | Ememl | end of mem low byte (Limit-of-memory) |
| 134 | 00:0086 | Ememh | end of mem high byte (Limit-of-memory) |
| 135 | 00:0087 | Clinel | current line low byte (Basic line number) |
| 136 | 00:0088 | Clineh | current line high byte (Basic line number) |
| 137 | 00:0089 | Blinel | break line low byte (Previous Basic line number) |
| 138 | 00:008A | Blineh | break line high byte (Previous Basic line number) |
| 139 | 00:008B | Cpntrl | continue pointer low byte |
| 140 | 00:008C | Cpntrh | continue pointer high byte |
| 141 | 00:008D | Dlinel | current DATA line low byte |
| 142 | 00:008E | Dlineh | current DATA line high byte |
| 143 | 00:008F | Dptrl | DATA pointer low byte |
| 144 | 00:0090 | Dptrh | DATA pointer high byte |
| 145 | 00:0091 | Rdptrl | read pointer low byte |
| 146 | 00:0092 | Rdptrh | read pointer high byte |
| 147 | 00:0093 | Varnm1 | current var name 1st byte |
| 148 | 00:0094 | Varnm2 | current var name 2nd byte |
| 149 | 00:0095 | Cvaral | current var address low byte |
| 150 | 00:0096 | Cvarah | current var address high byte |
| 151 | 00:0097 | Frnxtl | var pointer for FOR/NEXT low byte |
| 151 | 00:0097 | Tidx1 | temp line index |
| 151 | 00:0097 | Lvarpl | let var pointer low byte |
| 152 | 00:0098 | Frnxth | var pointer for FOR/NEXT high byte |
| 152 | 00:0098 | Lvarph | let var pointer high byte |
| 153 | 00:0099 | prstk | precedence stacked flag |
| 155 | 00:009B | comp\_f | compare function flag, bits 0,1 and 2 used |
|  |  |  | bit 2 set if > |
|  |  |  | bit 1 set if = |
|  |  |  | bit 0 set if < |
| 156 | 00:009C | func\_l | function pointer low byte |
| 157 | 00:009D | func\_h | function pointer high byte |
| 156 | 00:009C | garb\_l | garbage collection working pointer low byte |
| 157 | 00:009D | garb\_h | garbage collection working pointer high byte |
| 158 | 00:009E | des\_2l | string descriptor\_2 pointer low byte |
| 159 | 00:009F | des\_2h | string descriptor\_2 pointer high byte |
| 160 | 00:00A0 | g\_step | garbage collect step size |
| 161 | 00:00A1 | Fnxjmp | jump vector for functions |
| 162 | 00:00A2 | Fnxjpl | functions jump vector low byte |
| 162 | 00:00A2 | g\_indx | garbage collect temp index |
| 163 | 00:00A3 | Fnxjph | functions jump vector high byte |
| 163 | 00:00A3 | FAC2\_r | FAC2 rounding byte |
| 164 | 00:00A4 | Adatal | array data pointer low byte |
| 164 | 00:00A4 | Nbendl | new block end pointer low byte |
| 165 | 00:00A5 | Adatah | array data pointer high byte |
| 165 | 00:00A5 | Nbendh | new block end pointer high byte |
| 166 | 00:00A6 | Obendl | old block end pointer low byte |
| 167 | 00:00A7 | Obendh | old block end pointer high byte |
| 168 | 00:00A8 | numexp | string to float number exponent count |
| 168 | 00:00A8 | numbit | bit count for array element calculations |
| 169 | 00:00A9 | expcnt | string to float exponent count |
| 170 | 00:00AA | numdpf | string to float decimal point flag |
| 170 | 00:00AA | Astrtl | array start pointer low byte |
| 171 | 00:00AB | expneg | string to float eval exponent -ve flag |
| 171 | 00:00AB | Astrth | array start pointer high byte |
| 170 | 00:00AA | Histrl | highest string low byte |
| 171 | 00:00AB | Histrh | highest string high byte |
| 170 | 00:00AA | Baslnl | BASIC search line pointer low byte |
| 171 | 00:00AB | Baslnh | BASIC search line pointer high byte |
| 170 | 00:00AA | Fvar\_l | find/found variable pointer low byte |
| 171 | 00:00AB | Fvar\_h | find/found variable pointer high byte |
| 170 | 00:00AA | Ostrtl | old block start pointer low byte |
| 171 | 00:00AB | Ostrth | old block start pointer high byte |
| 170 | 00:00AA | Vrschl | variable search pointer low byte |
| 171 | 00:00AB | Vrschh | variable search pointer high byte |
| 172 | 00:00AC | FAC1\_e | FAC1 exponent |
| 173 | 00:00AD | FAC1\_1 | FAC1 mantissa1 |
| 174 | 00:00AE | FAC1\_2 | FAC1 mantissa2 |
| 175 | 00:00AF | FAC1\_3 | FAC1 mantissa3 |
| 176 | 00:00B0 | FAC1\_s | FAC1 sign (b7) |
| 172 | 00:00AC | str\_ln | string length |
| 173 | 00:00AD | str\_pl | string pointer low byte |
| 174 | 00:00AE | str\_ph | string pointer high byte |
| 174 | 00:00AE | des\_pl | string descriptor pointer low byte |
| 175 | 00:00AF | des\_ph | string descriptor pointer high byte |
| 175 | 00:00AF | mids\_l | MID$ string temp length byte |
| 177 | 00:00B1 | negnum | string to float eval -ve flag |
| 177 | 00:00B1 | numcon | series evaluation constant count |
| 178 | 00:00B2 | FAC1\_o | FAC1 overflow byte |
| 179 | 00:00B3 | FAC2\_e | FAC2 exponent |
| 180 | 00:00B4 | FAC2\_1 | FAC2 mantissa1 |
| 181 | 00:00B5 | FAC2\_2 | FAC2 mantissa2 |
| 182 | 00:00B6 | FAC2\_3 | FAC2 mantissa3 |
| 183 | 00:00B7 | FAC2\_s | FAC2 sign (b7) |
| 184 | 00:00B8 | FAC\_sc | FAC sign comparison, Acc#1 vs #2 |
| 185 | 00:00B9 | FAC1\_r | FAC1 rounding byte |
| 184 | 00:00B8 | ssptr\_l | string start pointer low byte |
| 185 | 00:00B9 | ssptr\_h | string start pointer high byte |
| 184 | 00:00B8 | sdescr | string descriptor pointer |
| 186 | 00:00BA | csidx | line crunch save index |
| 186 | 00:00BA | Asptl | array size/pointer low byte |
| 187 | 00:00BB | Aspth | array size/pointer high byte |
| 186 | 00:00BA | Btmpl | BASIC pointer temp low byte |
| 187 | 00:00BB | Btmph | BASIC pointer temp low byte |
| 186 | 00:00BA | Cptrl | BASIC pointer temp low byte |
| 187 | 00:00BB | Cptrh | BASIC pointer temp low byte |
| 186 | 00:00BA | Sendl | BASIC pointer temp low byte |
| 187 | 00:00BB | Sendh | BASIC pointer temp low byte |
| 188 | 00:00BC | LAB\_IGBY | get next BASIC byte subroutine |
| 194 | 00:00C2 | LAB\_GBYT | get current BASIC byte subroutine |
| 195 | 00:00C3 | Bpntrl | BASIC execute (get byte) pointer low byte |
| 196 | 00:00C4 | Bpntrh | BASIC execute (get byte) pointer high byte |
| 197 | 00:00C5 | Bpntrp | BASIC execute (get byte) pointer PAGE byte |
| 224 | 00:00E0 |  | end of get BASIC char subroutine |
| 225 | 00:00E1 | Rbyte4 | extra PRNG byte |
| 226 | 00:00E2 | Rbyte1 | most significant PRNG byte |
| 227 | 00:00E3 | Rbyte2 | middle PRNG byte |
| 228 | 00:00E4 | Rbyte3 | least significant PRNG byte |
| 229 | 00:00E5 | NmiBase | NMI handler enabled/setup/triggered flags |
|  |  |  | bit function |
|  |  |  | === ======== |
|  |  |  | 7 interrupt enabled |
|  |  |  | 6 interrupt setup |
|  |  |  | 5 interrupt happened |
| 230 | 00:00E6 |  | NMI handler addr low byte |
| 231 | 00:00E7 |  | NMI handler addr high byte |
| 232 | 00:00E8 | IrqBase | IRQ handler enabled/setup/triggered flags |
| 233 | 00:00E9 |  | IRQ handler addr low byte |
| 234 | 00:00EA |  | IRQ handler addr high byte |
| 235 | 00:00EB | FCBPTR | POINTER TO FCB FOR FILE OPS |
| 239 | 00:00EF | Decss | number to decimal string start |
| 240 | 00:00F0 | Decssp1 | number to decimal string start |
| 253 | 00:00FD | TEMPW |  |
| 255 | 00:00FF |  | decimal string end |
| 256-511 | 00:0100-00:01FF | 6502Stack | Left Free for 6502 Emulation Mode Stack |
| 512-767 | 00:0200-00:02FF | KEYBUFF | 256 BYTE KEYBOARD BUFFER |
|  |  |  | NATIVE VECTORS |
| 768 | 00:0300 | ICOPVECTOR | COP handler indirect vector... |
| 770 | 00:0302 | IBRKVECTOR | BRK handler indirect vector... |
| 772 | 00:0304 | IABTVECTOR | ABT handler indirect vector... |
| 774 | 00:0306 | INMIVECTOR | NMI handler indirect vector... |
| 776 | 00:0308 | IIRQVECTOR | IRQ handler indirect vector... |
|  |  |  | 6502 Emulation Vectors |
| 778 | 00:030A | IECOPVECTOR | ECOP handler indirect vector... |
| 780 | 00:030C | IEABTVECTOR | EABT handler indirect vector... |
| 782 | 00:030E | IENMIVECTOR | ENMI handler indirect vector... |
| 784 | 00:0310 | IEINTVECTOR | EINT handler indirect vector... |
|  |  |  | IEC Driver work Area |
| 786 | 00:0312 | IECDCF | Serial output: deferred char flag |
| 787 | 00:0313 | IECDC | Serial deferred character |
| 788 | 00:0314 | IECBCI | Serial bit count/EOI flag |
| 789 | 00:0315 | IECBTC | Countdown, bit count |
| 790 | 00:0316 | IECCYC | Cycle count |
| 791 | 00:0317 | IECSTW | Status word |
| 792 | 00:0318 | IECFNLN | File Name Length |
| 793 | 00:0319 | IECSECAD | IEC Secondary Address |
| 794 | 00:031A | IECBUFFL | low byte IEC buffer Pointer |
| 795 | 00:031B | IECBUFFH | High byte IEC buffer Pointer |
| 796 | 00:031C | IECDEVN | IEC Device Number |
| 797 | 00:031D | IECSTRTL | low byte IEC Start Address Pointer |
| 798 | 00:031E | IECSTRTH | High byte IEC Start Address Pointer |
| 799 | 00:031F | IECMSGM | message mode flag, |
|  |  |  | $C0 = both control and kernal messages, |
|  |  |  | $80 = control messages only, |
|  |  |  | $40 = kernal messages only, |
|  |  |  | $00 = neither control or kernal messages |
| 800 | 00:0320 | IECFNPL | File Name Pointer Low, |
| 801 | 00:0321 | IECFNPH | File Name Pointer High, |
| 802 | 00:0322 | LOADBUFL | low byte IEC buffer Pointer |
| 803 | 00:0323 | LOADBUFH | High byte IEC buffer Pointer |
| 804 | 00:0324 | LOADBANK | BANK buffer Pointer |
| 805 | 00:0325 | IECOPENF | OPEN FILE COUNT |
| 806 | 00:0326 | IECLFN | IEC LOGICAL FILE NUMBER |
| 807 | 00:0327 | IECIDN | input device number |
| 808 | 00:0328 | IECODN | output device number |
|  |  |  | VIDEO/KEYBOARD PARAMETER WORK AREA |
| 816 | 00:0330 | CSRX | CURRENT X POSITION |
| 817 | 00:0331 | CSRY | CURRENT Y POSITION |
| 818 | 00:0332 | LEDS | Current Keyboard LED status |
| 819 | 00:0333 | KeyLock | Current Keylock status |
| 820 | 00:0334 | ScannedKey | Current Scanned Key |
| 821 | 00:0335 | ScrollCount | Current Scroll Count |
| 822 | 00:0336 | TEMP | TEMP AREA |
| 833 | 00:0341 | ConsoleDevice | Current Console Device |
|  |  |  | $00 Serial, $01 On-Board 9918/KB |
| 834 | 00:0342 | CSRCHAR | Character under the Cursor |
| 835 | 00:0343 | VIDEOWIDTH | SCREEN WIDTH -- 32 or 40 (80 in the future) |
| 848 | 00:0350 | ScrollBuffer | at least 80 bytes? |
| 944 | 00:03B0 | PTRLFT | .. to $03B9 logical file table |
| 954 | 00:03BA | PTRDNT | .. to $03C3 device number table |
| 964 | 00:03C4 | PTRSAT | .. to $03CD secondary address table |
| 976-1000 | 00:03D0-00:03E9 | LINEFLGS | 24 BYTES OF LINE POINTERS (3D0 - 3E9 , one ext |
|  |  |  |  |
| 1001-32767 | 00:03F0-00:7FFF |  | OPEN/STACK |
|  |  |  |  |
| 32767 | 00:7FFF | STACK | TOP OF 65816 STACK |
| 32768-65535 | 00:8000-00:FFFF | ROM |  |
| 32768-37611 | 00:8000-00:92EB | SUPERMON | ROM: SUPERMON |
| 57344-65535 | 00:e000-00:FFFF | BIOS | ROM: BIOS |
|  |  |  |  |
|  |  |  | IO Area |
| 65024 | 00:FE00 | UART0: | DATA IN/OUT |
| 65025 | 00:FE01 | UART1: | CHECK RX |
| 65026 | 00:FE02 | UART2: | INTERRUPTS |
| 65027 | 00:FE03 | UART3: | LINE CONTROL |
| 65028 | 00:FE04 | UART4: | MODEM CONTROL |
| 65029 | 00:FE05 | UART5: | LINE STATUS |
| 65030 | 00:FE06 | UART6: | MODEM STATUS |
|  |  |  |  |
| 65034 | 00:FE0A | DATAP: | VDP Data port |
| 65035 | 00:FE0B | CMDP: | VDP Command port |
|  |  |  |  |
| 65040 | 00:FE10 | via1regb | Register (Sound Data) |
| 65041 | 00:FE11 | via1rega | Register (IEC,RTC, & Sound) |
|  |  |  | B0 - Serial Clock in |
|  |  |  | B1- Serial Data in |
|  |  |  | B2- Sound BDIR |
|  |  |  | B3- Sound BC1 |
|  |  |  | B4- Sound BC2 |
|  |  |  | B5- RTC DQ |
|  |  |  | B6- RTC RST |
|  |  |  | B7 - Serial ATN Out |
| 65042 | 00:FE12 | via1ddrb | Register |
| 65043 | 00:FE13 | via1ddra | Register |
| 65044 | 00:FE14 | via1t1cl | Register |
| 65045 | 00:FE15 | via1t1ch | Register |
| 65046 | 00:FE16 | via1t1ll | Register |
| 65047 | 00:FE17 | via1t1lh | Register |
| 65048 | 00:FE18 | via1t2cl | Register |
| 65049 | 00:FE19 | via1t2ch | Register |
| 65050 | 00:FE1A | via1sr | Register |
| 65051 | 00:FE1B | via1acr | Register |
| 65052 | 00:FE1C | via1pcr | Register |
| 65053 | 00:FE1D | via1ifr | Register |
| 65054 | 00:FE1E | via1ier | Register |
| 65055 | 00:FE1F | via1ora | Register |
|  |  |  |  |
| 65056 | 00:FE20 | via2regb | Register (KB ROW & LED control) |
| 65057 | 00:FE21 | via2rega | Register (KB Column) |
| 65058 | 00:FE22 | via2ddrb | Register |
| 65059 | 00:FE23 | via2ddra | Register |
| 65060 | 00:FE24 | via2t1cl | Register |
| 65061 | 00:FE25 | via2t1ch | Register |
| 65062 | 00:FE26 | via2t1ll | Register |
| 65063 | 00:FE27 | via2t1lh | Register |
| 65064 | 00:FE28 | via2t2cl | Register |
| 65065 | 00:FE29 | via2t2ch | Register |
| 65066 | 00:FE2A | via2sr | Register |
| 65067 | 00:FE2B | via2acr | Register |
| 65068 | 00:FE2C | via2pcr | Register |
| 65069 | 00:FE2D | via2ifr | Register |
| 65070 | 00:FE2E | via2ier | Register |
| 65071 | 00:FE2F | via2ora | Register |
|  |  |  |  |
|  | 01:0000-07:FFFF | RAM |  |
|  | FF:0000-FF:FFFF | BASIC ROM |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  | BIOS Jump Table (Native Long JSR) |
|  |  |  |  |
| 64768 | 00:FD00 | LPRINTVEC | Print a character to the active console |
| 64772 | 00:FD04 | LINPVEC | Get a character from the active console (no wait) |
| 64776 | 00:FD08 | LINPWVEC | Get a character from the active console (wait) |
| 64780 | 00:FD0C | LSetXYVEC | Set the Cursor position on the 9918 screen |
| 64784 | 00:FD10 | LCPYVVEC | Copy 9918 VRAM |
| 64788 | 00:FD14 | LSrlUpVEC | Scroll up the 9918 Screen |
| 64792 | 00:FD18 | LSetColorVEC | Set the Color for the 9918 Screen |
| 64796 | 00:FD1C | LCURSORVEC | Turn on the 9918 Cursor |
| 64800 | 00:FD20 | LUNCURSORVEC | Turn Off the 9918 Cursor |
| 64804 | 00:FD24 | LWRITERTC | Write a RTC register |
| 64808 | 00:FD28 | LREADRTC | Read a RTC register |
| 64812 | 00:FD2C | LIECIN | Read byte from serial bus. (Must call TALK and TALKSA beforehands.) |
| 64816 | 00:FD30 | LIECOUT | Write byte to serial bus. (Must call LISTEN and LSTNSA beforehands.) |
| 64820 | 00:FD34 | LUNTALK | Send UNTALK command to serial bus. |
| 64824 | 00:FD38 | LUNLSTN | Send UNLISTEN command to serial bus. |
| 64828 | 00:FD3C | LLISTEN | Send LISTEN command to serial bus. |
| 64832 | 00:FD40 | LTALK | Send TALK command to serial bus. |
| 64836 | 00:FD44 | LSETLFS | Set file parameters. |
| 64840 | 00:FD48 | LSETNAM | Set file name parameters. |
| 64844 | 00:FD4C | LLOAD | Load or verify file. (Must call SETLFS and SETNAM beforehand.) |
| 64848 | 00:FD50 | LSAVE | Save file. (Must call SETLFS and SETNAM beforehand.) |
| 64852 | 00:FD54 | LIECINIT | INIT IEC |
| 64856 | 00:FD58 | LIECCLCH | close input and output channels |
| 64860 | 00:FD5C | LIECOUTC | open a channel for output |
| 64864 | 00:FD60 | LIECINPC | open a channel for input |
| 64868 | 00:FD64 | LIECOPNLF | open a logical file |
| 64872 | 00:FD68 | LIECCLSLF | close a specified logical file |
| 64876 | 00:FD6C | LClearScrVec | clear the 9918 Screen |
| 64880 | 00:FD70 | LLOADFONTVec | LOAD THE FONT |
|  |  |  |  |
|  |  |  | BIOS Jump Table (Emulation, short JSR) |
| 65393 | 00:FF71 | PRINTVEC | Print a character to the active console |
| 65396 | 00:FF74 | INPVEC | Get a character from the active console (no wait) |
| 65399 | 00:FF77 | INPWVEC | Get a character from the active console (wait) |
| 65402 | 00:FF7A | SetXYVEC | Set the Cursor position on the 9918 screen |
| 65405 | 00:FF7D | CPYVVEC | Copy 9918 VRAM |
| 65408 | 00:FF80 | SrlUpVEC | Scroll up the 9918 Screen |
| 65411 | 00:FF83 | SetColorVEC | Set the Color for the 9918 Screen |
| 65414 | 00:FF86 | CURSORVEC | Turn on the 9918 Cursor |
| 65417 | 00:FF89 | UNCURSORVEC | Turn Off the 9918 Cursor |
| 65420 | 00:FF8C | WRITERTC | Write a RTC register |
| 65423 | 00:FF8F | READRTC | Read a RTC register |
| 65426 | 00:FF92 | IECIN | Read byte from serial bus. (Must call TALK and TALKSA beforehands.) |
| 65429 | 00:FF95 | IECOUT | Write byte to serial bus. (Must call LISTEN and LSTNSA beforehands.) |
| 65432 | 00:FF98 | UNTALK | Send UNTALK command to serial bus. |
| 65435 | 00:FF9B | UNLSTN | Send UNLISTEN command to serial bus. |
| 65438 | 00:FF9E | LISTEN | Send LISTEN command to serial bus. |
| 65441 | 00:FFA1 | TALK | Send TALK command to serial bus. |
| 65444 | 00:FFA4 | SETLFS | Set file parameters. |
| 65447 | 00:FFA7 | SETNAM | Set file name parameters. |
| 65450 | 00:FFAA | LOAD | Load or verify file. (Must call SETLFS and SETNAM beforehand.) |
| 65453 | 00:FFAD | SAVE | Save file. (Must call SETLFS and SETNAM beforehand.) |
| 65456 | 00:FFB0 | IECINIT | INIT IEC |
| 65459 | 00:FFB3 | IECCLCH | close input and output channels |
| 65462 | 00:FFB6 | IECOUTC | open a channel for output |
| 65465 | 00:FFB9 | IECINPC | open a channel for input |
| 65468 | 00:FFBC | IECOPNLF | open a logical file |
| 65471 | 00:FFBF | IECCLSLF | close a specified logical file |
| 65474 | 00:FFC2 | ClearScrVec | clear the 9918 Screen |
| 65477 | 00:FFC5 | LOADFONTVec | LOAD THE FONT |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  | VRAM Memory Map |  |
| 0-1023 | $0000-$03FF |  | Sprite Patterns |
| 1024-1983 | $0400-$07BF |  | Screen Memory  ($06FF for Graphics Modes) |
| 1792-2047 | $0700-$07FF |  | Sprite Attributes |
| 2048-8191 | $0800-$1FFF |  | Patterns |
| 8192-16385 | $2000-$3FFF |  | Color Memory |