

# The BASIC816 Language Manual

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## About BASIC816

BASIC816 is an implementation of the BASIC programming language for the Western Design Center's 65816 micro-processor. It is focused on providing a simple BASIC interpreter for the C256 Foenix computer designed by Stefany Allaire. BASIC816 has a few design goals and even a couple of anti-goals:

- It should provide a retro-computing feel.
- It should be simple to use and easy to learn.
- It should provide essential access to storage and the C256's abilities.
- It should be expandable, allowing advanced users to customize it or extend it.
- It should be a clean-room implementation, unencumbered by copy-right.
- It need not be the fastest programming language available.
- It need not provide all the advancements in programming languages developed since the 1980s.

As such, BASIC816 is a fairly traditional, tokenized, line-number based implementation of BASIC, similar to those implementation of BASIC on the 8-bit computers of the 1970s and 1980s.

## Screen Editing

BASIC816 for the C256 includes a simple screen editor. To enter a program, just type the lines, being sure to press the return key at the end of each line. The interpreter will not attempt to process the line until you press return, and the text it will process is whatever text is on the line of the screen where your cursor is. If you need to edit a line that's on the screen, you can use the cursor keys to move to the line and make your change. A few other special keys are supported:

**Arrow Keys** The arrow keys will move the cursor on the screen in a natural fashion.

**Backspace** The backspace key deletes the character to the left of the cursor.

**Delete** The delete key deletes the character under the cursor.

**Insert** The insert key inserts a space at the cursor (pushing the character that was under the cursor to the right).

Although not an edit key, the SysRq key is currently assigned as a "programmer's key" and will interrupt the currently running BASIC program and open the monitor. It should work for any program (even machine language), so long as the keyboard interrupt logic has not been intercepted. Likewise, the Scroll Lock key will pause any screen output from the interpreter while it is on. This includes output from a program that is producing a lot of text and even program listings.

## Data Types

BASIC816 supports three data types:

**Integer** The integers in BASIC816 are 32-bit signed integers and may have values from  $-2,147,483,648$  to  $2,147,483,647$ . Examples of integers are 0, 1, 42,  $-1$ ,  $-128$ .

**String** Text data are stored in strings. A string may be entered into a BASIC816 program by enclosing it in double quote marks. Strings are represented internally as null-terminated ASCII strings, that is, there is no length data on the string, the end of which is marked by a 0 byte. Strings may be up to 65536 bytes in length.

**Array** Arrays allow multiple data items to be stored under a single name and accessed by an index. Two types of arrays are supported: arrays of integer and arrays of strings. Arrays may be just one-dimensional, using a single number as index, or they may be multi-dimensional, where each element has a unique combination of numbers serving as an index.

Note: when BASIC816 leaves the alpha stage of development, it will include a fourth type: 32-bit floating point numbers as well as arrays of 32-bit floating point numbers.

## Literal Values

Integers and strings may both be entered directly into programs as literal values. Strings are designated with double quote marks, but there is no character escape syntax as in other languages. If you need to enter a character you cannot type, you will have to use the CHR\$ function. Integers may be entered as a sequence of digits with an optional minus sign at the start. The default base for integers is decimal, but hexadecimal numbers may be entered with the &H prefix.

- "Hello, world!"
- 12345
- -562
- &HFFD2

## Variables

A BASIC816 program can assign data to variables using the LET statement or an implicit LET statement. Variables need not be declared before use, with the exception of array variables, which must be declared through the DIM statement.

Variable names may be up to eight characters long. The first character must be an alphabetic character from A through Z. Subsequent characters of the name may be A–Z, 0–9, or the underscore character (\_). The type of the variable is indicated by a character at the end of the variable name. Integer variables are indicated by the percent sign (%), and string variables are indicated by the dollar sign (\$). These type designations must be used in all references to the variable and may be considered as part of the name. This means that a program can have six different variables with the same “name” but different types (e.g. A, A%, A\$, A(), A%(), and A\$()).

## Expressions

An expression is a sequence of values, operators, and function calls which will have some data value as a *result*. An expression may have a numeric (integer) result or a text (string) result.

Operators are common mathematical symbols which will perform some sort of computation on two values. These are the usual sort of thing: addition, subtraction, multiplication, division, and so on. Operators are typically evaluated left to right, but have an operator precedence which can alter the order of execution. For instance multiplication operators are evaluated before addition. This precedence can be altered by using parentheses to enclose a sub-expression that should be evaluated as a unit.

## Commands

Commands in BASIC816 are keywords which triggers some action but which may only be used at the interactive prompt. Commands may not be used within a BASIC816 program.

Operators	Purpose
<code>^</code>	Exponent
<code>*</code> , <code>/</code> , <code>MOD</code>	Multiply, Divide, modulo
<code>+</code> , <code>-</code>	Addition, Subtraction
<code>&lt;</code> , <code>&gt;</code> , <code>=</code> , <code>&lt;=</code> , <code>&gt;=</code> , <code>&lt;&gt;</code>	Comparison operators
<code>NOT</code>	Bitwise Negation
<code>AND</code>	Bitwise AND
<code>OR</code>	Bitwise OR

Table 1: Operators in order of descending precedence.

## CONT

Continue execution of the current program from the point immediately after the STOP statement that was executed. It is an error to use this command if the current program was not interrupted by the STOP command or if there is no current program.

## DIR

Print a listing of the files on the current file device.

## NEW

NEW clears all of BASIC816's memory. All program and variable data are erased, and a new program may be entered.

## LIST [`<start>`] [`- <end>`]

LIST types a program listing to the console screen. It accepts two optional line-numbers to limit the listing. The first line number specifies the smallest line number to list; if it is not specified, there is no lower limit. The second line number specifies the largest line number to list; if it is not specified, there is no upper limit.

## LOAD `<filename>`

Load the BASIC program with the given file name.

## SAVE `<filename>`

Save the BASIC program to storage with the given file name. The file must not already exist.

## RUN

Starts execution of the program from the first line of the code.

## Statements

Statements are keywords which trigger some action and may be used either at the interactive prompt or within a program. A BASIC816 program can be seen as a series of lines, each of which must have one or more statements on it. If a line has more than one statement, each statement is separated from the next by a colon (:).

BLOAD <filename> [, <destination>]

Loads a binary file into memory starting at the specified <destination> address in memory. If there is no provided <destination>, the file format loaded must have its own destination address embedded within it. Currently, only the PGX format is supported, but others may be supported in future.

BRUN <filename>

Load the binary file specified into memory and attempt to execute it. The file must be in an executable format, which means that it must contain its own destination address and information on how to start it. Currently, only the PGX format is supported, but others may be supported in the future.

BSAVE <filename>, <start>, <end>

Save the data in memory from address <start> to address <end> (inclusive) to a binary file. The file must not already exist.

CLR

Erases all variable definitions. Any variable that was defined prior to the use of CLR will be undefined. Also all data stored directly or indirectly through variables will be returned to free memory. This is similar to NEW, except that the program may be running and is left intact.

CLS

Clears the text screen and moves the cursor to the home position.

CALL <address>[, <a>[, <x>[, <y>]]]

Call a machine language subroutine at <address>. If the subroutine returns at all to the caller, it must return using the RTL instruction. Values may be provided for the A, X, and Y registers and may be 16-bit values.

DATA <value>[, ...]

Provide numeric or string data in the program which may be retrieved into a variable using the READ statement.

DEL <filename>

Delete a file from the storage device.

DIM <variable>(<size>[, ...])

Declare an array named <variable>. The array can have many dimensions, each with the size provided. An array can have up to 127 dimensions, and the size can be up to 256, but in practice the entire block of memory consumed by the array cannot exceed 65,536 bytes (including the “book keeping” memory allocated to keep track of the array (which is at most 256 bytes).

END

Stops execution of the program. The only way to restart execution after END has been executed is to use the RUN command.

FOR <variable> = <initial> TO <target> [STEP <increment>]

The FOR statement marks the beginning of a loop that will repeat a specified number of times. It starts by assigning an <initial> value to a <variable> and executing the following statement until the matching NEXT statement is encountered. It will then either add 1 to <variable> or <increment>, if provided. So long as <variable> is not <target>, the statements between the FOR and NEXT will be executed.

GET <variable>

Waits for the user to press a key, then assigns the character of that key to the string <variable> provided.

GOTO <line number>

Continue execution with the first statement on the line with the given <line number>. It is an error to GOTO a <line number> that does not exist in the program.

GOSUB <line number>

Call a subroutine starting at the line with the given <line number>. A subsequent RETURN statement will return the program to the statement following the GOSUB. It is an error to GOSUB a <line number> that does not exist in the program.

IF <expr> THEN <line>

Evaluates <expr> and examines the result. If the result is not zero, execution continues with the first statement on the line with number <line>. Otherwise, execution continues with the next statement after the IF.

Note: This statement will be receiving considerable improvements in subsequent versions of BASIC816.

INPUT [ <message>; ] <variable>

If a literal string message is provided, print the message followed by a question mark. If no message is provided, just print a question mark. In either case, wait for the user to type a line of input on the keyboard and put the value typed into the provided variable.

NOTE: Currently, this statement supports only string values and variables.

NEXT

Close the matching FOR loop.

POKE <address>, <value>

Write the 8-bit <value> to the memory location at <address>. It is an error to try to write a value that requires more than 8-bits.

POKEW <address>, <value>

Write the 16-bit <value> to the memory location at <address>. The low byte of <value> will be written to <address>, and the high byte of <value> will be written to the following byte in memory. It is an error to try to write a value that requires more than 16-bits.

**POKEL <address>, <value>**

Write the 24-bit <value> to the memory location at <address>. The low byte of <value> will be written to <address>, and the middle byte of <value> will be written to the following byte in memory, and the high byte of <value> will be written to the next byte in memory. It is an error to try to write a value that requires more than 24-bits.

**PRINT [<value> [, /;]] ...**

Write the textual representation of <value> to the screen. If more than one <value> is provided, they must be separated by either a comma (,) or a semicolon (;). If a comma is used, the two items will be separated by a TAB. If a semicolon is used, the two items will be printed one after the other. A PRINT statement will print a carriage return as the last thing, unless the statement is ended with a semicolon.

**REM <comment>**

Inserts a comment into the BASIC816 program. All characters after the REM until end of the line will be ignored.

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

Read one of more values out of the DATA statements in the program into <variable>. The data read must have a compatible type to the variable. Each variable read will advance a data cursor forward one data element. If a READ is executed when the cursor has reached the end of the data elements, it is an error.

**RESTORE**

Resets the data cursor to the first data element of the first DATA statement.

**STOP**

Stops execution of the program in such a way that the user can restart it with the CONT command.

## Functions

**ABS(<value>)**

Returns the absolute value of <value>. If the parameter is negative, it is converted to its positive equivalent (for instance, ABS(-5) will evaluate to 5).

**ASC(<text>)**

Returns the ASCII code for the first character of <text>. Example: ASC("A") returns 65.

**CHR\$(<value>)**

Returns the character corresponding to the ASCII code in <value>. Example: CHR\$(65) returns "A".

**DEC(<hex>)**

Returns an integer that is conversion of the hexadecimal number in the string <hex>. Example: DEC("A0") returns 160.

HEX\$(<value>)

Returns a string that is the hexadecimal representation of the integer value passed. Example: HEX\$(160) returns "A0".

LEFT\$(<text>, <count>)

Returns the left-most <count> characters of the string <text>.

Example: LEFT\$("Hello", 3) returns "Hel".

MID\$(<text>, <first>, <count>)

Returns a substring of the string <text>. The parameter <first> specifies the number of the first character to use, where a 0 is the number of the first character in the source string. The parameter <count> indicates how many characters should be returned.

Example: MID\$("Hello", 2, 3) returns "llo".

PEEK(<address>)

Returns the byte stored in memory at location <address>.

PEEKW(<address>)

Returns the 16-bit word stored in memory at location <address>. The low byte of the returned value is at <address>, and the high byte is at address + 1.

PEEKL(<address>)

Returns the 24-bit word stored in memory at location <address>. The low byte of the returned value is at <address>, the middle byte is at address + 1, and the high byte is at address + 2.

RIGHT\$(<text>, <count>)

Returns the right-most <count> characters of the string <text>.

Example: RIGHT\$("Hello", 3) returns "llo".

SGN(<value>)

Returns the sign of the number <value>. If the number is negative, the result is -1, if the number is positive, the result is 1, and if the number is zero, the result is 0.

Example: SGN(-25) returns -1.

SPC(<value>)

Returns a string containing <value> spaces.

Example: SPC(5) returns a string of five spaces.

STR\$(<value>)

Returns a string containing the decimal representation of the number <value>.

Example: STR\$(25) returns "25".



TAB(<value>)

Returns a string containing <value> TAB characters.

Example: TAB(2) returns a string of two TABs.

VAL(<text>)

Returns the numeric value represented by the string of decimal digits in <text>.

Example: VAL("42") returns 42.

## C256 Specific Statements

BASIC816 includes a number of statements to support features of the C256 Foenix.

CLRPIXMAP

Sets all pixels in the bitmap to 0 (transparent). The bitmap must have been setup with the PIXMAP statement before this statement can be used.

FILL <x0>, <y0>, <x1>, <y1>, <color>

Fill the rectangle with corners at  $(x_0, y_0)$  to  $(x_1, y_1)$  with the color specified by the <color> index number. The actual color displayed will depend on the RGB values provided for that index in the color lookup table currently used by the bitmap. The PIXMAP statement must have been used before using this statement.

GRAPHICS <mode>

Sets the graphics mode of the Vicky chip. This statement just sets the master control register of the Vicky chip to whatever value is provided in <mode>, which should be a number in the range 0–255.

The bits of the master control register can be seen described in Table 2.

Bit	Purpose
7	Global disable: If set, this disables all Vicky output.
6	Gamma Correction: If set, this enables gamma correction.
5	Sprites: If set, this enables the sprite engine.
4	Tiles: If set, this enables the tile engine.
3	Bitmap: If set, this enables the bitmap engine.
2	Graphics: If set, this enables the graphics blocks.
1	Text Overlay: If set, text will be displayed over graphics.
0	Text: If set, this enables the text display engine.

Table 2: Vicky Master Control Register

LINE <x0>, <y0>, <x1>, <y1>, <color>

Draw a line on the bitmap display from positions  $(x_0, y_0)$  to  $(x_1, y_1)$  in the color specified by the <color> index number. The actual color displayed will depend on the RGB values provided for that index in the color lookup table currently used by the bitmap. The PIXMAP statement must have been used before using this statement.

MONITOR

Enter the machine language monitor.

PIXMAP <visible>, <lut> [, <address>]

Controls the visibility of the bitmap display (the bitmap engine must be enabled with the GRAPHICS command). The parameter <visible> must be a number. If it is 0, the bitmap will be hidden. If it is any other value, it will be shown.

The number of the color lookup table to use must also be provided as <lut>, which must be the number of one of the graphics color lookup tables.

Optionally, an address may be provided for the first byte of the bitmap. This address must be in the video memory area starting at B00000. If no address is provided, it will default to B00000.

PLOT <column>, <row>, <color>

Set the pixel at the specified <row> and <column> to the color with the given <color> index number. The actual color displayed will depend on the RGB values provided for that index in the color lookup table currently used by the bitmap. The PIXMAP statement must have been used before using this statement.

SETBGCOLOR <red>, <green>, <blue>

Sets the background color to be used in graphics modes. The color is specified as red, green, and blue components, all of which must be in the range 0 – 255.

SETBORDER <visible> [, <red>, <green>, <blue> ]

Sets the visibility and, optionally, color of the border of the C256's screen, given <red>, <green>, and <blue> intensity values, which must be between 0–255. The parameter <visibility> must be a number: if it is 0, the border will not be shown; if it is any other number, the border will be visible.

SETDATE <day>, <month>, <year>

Sets the date on the C256's real time clock, given the date as three numbers: <day>, <month>, and <year>. The day number must be from 1–31. The month number must be from 1–12. The year number must be from 0–99.

SETCOLOR <lut>, <color>, <red>, <green>, <blue>

Define the RGB intensities for a color in one of the Vicky chip's color lookup tables. The color lookup table is a number <lut> in the range 0–9. The number of the color to change is <color>, which is in the range 0–255 for all graphics lookup tables and 0–14 for the two text mode lookup tables. The RGB intensities are provided by the parameters <red>, <green>, and <blue>, which must be in the range 0–255.

The association of <lut> number to the color lookup table in Vicky is shown in Table 3.

LUT	Lookup Table	Max Color
0	Graphics LUT 0	255
1	Graphics LUT 1	255
2	Graphics LUT 2	255
3	Graphics LUT 3	255
4	Graphics LUT 4	255
5	Graphics LUT 5	255
6	Graphics LUT 6	255
7	Graphics LUT 7	255
8	Text Foreground LUT	15
9	Text Background LUT	15

Table 3: Color lookup table numbers

SPRITE <number>, <lut> [, <address> ]

Set the color lookup table and the address for sprite <number>. The parameter <lut> must be the number of the graphics lookup table the sprite should use (0–7). The optional parameter <address> would be the first byte of the sprite's bitmap data and must be an address in the video RAM (starting at address B00000). If no address is provided, the sprite will default to B00000.

SPRITEAT <number>, <column>, <row>

Sets the location of a sprite. The sprite to move is <number>. Its upper-left corner will be set to <row> and <column>.

SPRITESHOW <number>, <visible> [, <layer> ]

Controls the visibility of sprite <number>. If <visible> is 0, the sprite will not be visible. If it is any other number, the sprite will be visible. Optionally, the display priority <layer> may be set, which will control which sprites and tiles this sprite will display in front of or behind when they overlap.

TEXTCOLOR <foreground>, <background>

Sets the color for text to be printed. The foreground color index is specified by <foreground>, and the background color index is specified by <background>. Both values must be in the range 0 – 15.

SETTIME <hour>, <minute>, <second>

Sets the time on the C256's real time clock, given the time as three numbers: <hour>, <minute>, and <second>.

## C256 Specific Functions

GETDATE\$(0)

Returns the current date from the C256's real time clock as a string in "DD:MM:YY" format.

GETTIME\$(0)

Returns the current time from the C256's real time clock as a string in "HH:MM:SS" format.

## File Format: PGX

The C256 Foenix supports a simple executable format: PGX. This format is intended as an elaboration on the PRG format from the Commodore computers in that it provides for a single block of data to load starting from an included destination address. To support the 65816 (and possibly other processors), it uses a 32-bit address field and has a signature and target CPU preamble. The first three bytes are the signature in ASCII: "PGM". The next byte is the target version and CPU, where the upper 4-bits is the version of the file format, and the lower 4-bits is the CPU code. Currently, the only CPU supported is 1 for 65816. The next four bytes are the starting destination address. The rest of the bytes in the file are the data to load. See table 4.

## Proposed: Extentions

The following is a proposal for an extension mechanism BASIC816 may provide in the future. It is not currently implemented in the interpreter.

While BASIC816 allows a program to use CALL to run any machine code loaded into memory, this does not extend the language. For more complex integration of machine language and BASIC, the interpreter will allow for

Offsets	Value	Purpose
0-2	"PGM"	Type signature
3	0x01	Target version and CPU
4-7	address	Destination address
8-	data	Data to load

Table 4: PGX File Format

the program to load a binary file containing code for extending the commands, statements, and functions of the interpreter. An extension may be loaded with the statement:

`EXTENSION <path>`

Executing this statement will load the extension file off the storage device, given its path. The statement will also implicitly execute a CLR statement, removing all variable definitions and heap storage objects. The reason for this is that the extensions will be loaded into what would be the top of the heap, and the heap will need to be moved down to accomodate the extension. Therefore, if a program needs to use an extension, the first thing it should do is to load the extension.

Note that multiple extensions can be loaded at one time. The interpreter will assign an extension token sequence to each keyword defined by the extensions. Since multiple extensions can be used, the token sequence can vary from program to program. That means that if an extension provides a statement `PLAY`, it might have the token `$F1` in one program, but in another program, it might have the token `$F8`.

## Coding an Extension

An extension will be a binary file on a storage device (SD Card, floppy disk, hard drive). Each extension will be loaded into its own memory bank of 64KB. The extension will have free use of all memory within that bank for whatever purpose it desires. The beginning of that memory bank must be laid out in a particular structure, however (see below). While the extension will always be loaded so that the first byte of the file corresponds to the first byte of the bank, the particular bank the extension will be loaded into will be determined at runtime by the interpreter. The memory size of the computer and the load order of other extensions the program may use can affect the particular bank used. All addresses used by the extension for accessing its own memory should therefore be 16-bit addresses (*e.g.* bank relative, PC relative, *etc.*).

The following pseudo-C code is a simple map of the an extension, starting with byte 0:

```
struct {
    char magic[3];           // A three-character magic code indicating this is an extension
    uint8_t version;         // A single byte version code for the extension format
    uint16_t init_ptr;       // A 16-bit offset to any initialization code (0 if none)
    struct {
        uint8_t type;        // A byte indicating the type of the token (statement, comment, function, c
        uint16_t name_ptr;   // A 16-bit offset to an ASCIIZ string for the keyword of the token
        uint16_t exec_ptr;   // A 16-bit offset to the code to call to evaluate the token
    } tokens[];
    uint8_t eot;             // Always equal to $FF
    uint8_t code[];         // The code for the extension
}
```

The first three bytes are the required magic number (TBD), identifying the file as a BASIC816 extension. The fourth byte is a binary version number. It will be `$00` for the first version. If there are any changes to the extension layout, they can be flagged here.

Next comes an offset pointer (16-bits) to an initialization routine that will be called when the extension has been loaded but before the EXTENSION statement completes execution. This can be used for any sort of set up housekeeping the extension needs to do. If there is nothing to do here, the offset should be set to \$0000.

Next comes a token record, one per keyword provided by the extension. The record contains a byte indicating what type of keyword is being defined (statement, function, command, operator, or even punctuation). The next byte indicates the evaluation precedence (relevant for operators). Then there is a 16-bit offset pointer to the name of the keyword (an upper-case ASCII string). Then there is a 16-bit offset pointer to the code to execute when executing the keyword. The subroutine at that location should return with an RTL instruction.

After all the token records have been provided, the next byte should be \$FF to indicate there are no more records to process. All other bytes in the file after that point are left for the extension's use. They may be arranged however the extension author desires.

## C256 Character Set

The character set for BASIC816 on the C256 is assumed to be ASCII, with each character taking a full 8-bit byte. There are a number of special characters the system supports, shown in Table 5.

Code	Purpose
0x08	Delete character to the left and move cursor left
0x09	Move cursor to next tab
0x0A	Line Feed
0x0D	Carriage Return
0x11	Move cursor up a line
0x1D	Move cursor right one column
0x91	Move cursor down a line
0x9D	Move the cursor left one column

Table 5: Special Character Codes