SYSMON65 Guide

Version 1.02

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Overview

SYSMON65 was developed for my 65C02 single board computer (SBC). My SBC contains a the venerable 65C02 processor, a 6551 (ACIA), a 6522 (VIA), and the core chips found in most SBCs which typically include, a ROM (27C256) chip, a RAM chip, and address decoding logic chips.

This monitor may be ported to other 65C02 based SBCs with a few minor modifications. Other SBCs include the KIM-1, Apple II series computers, the Commodore 64, the VIC-20, and more.

After searching the internet and reviewing the few 6502 operating systems and monitor software that I could find, I discovered that I only liked some of the functionality of each. Therefore, I decided to develop my own monitor software. During early development, the memory footprint of the monitor software was not considered, but as development progressed this became a priority, so I kept the code size "real tight"!

My goal for *SYSMON65* is to be a software development tool on an SBC. The user may paste code into the terminal, compile code, do memory dumps, decode, edit code, and much more…

Parts of my code was inspired by the following:

- The *A1 Assembler* by San Bergmans.
  I like the front-end editor, but the assembler does not come with a dissembler. The assembler is a 2-pass assembler and feels very solid, but it was written primarily for an Apple computer. With San's permission I used his front-end editor code, reviewed every line, and eventually re-wrote most of this.

- The KRUSADER by Ken Wessen
  This has a super-efficient disassembler (most likely created by MOS and used by Apple) and includes the specific 65C02 instructions. With respect, I didn't like the front-end editor.

The look and feel of *SYSMON65* were heavily influenced by the famous line-oriented debugger Debug https://en.wikipedia.org/wiki/Debug_(command) found in DOS (those were the days!). Some *Debug* front-end functionality can be found in *SYSMON65*, including the [Backspace] key to fix mistypes, and command history functionality with the [Up arrow] key.

SYSMON65 is a full 2-pass assembler, with local and global labels, directives, and more. A 65C02 disassembler is included which includes Step-By-Step debugging (i.e., Tracing), memory dump, ASCII dump, fill, delete, block move, intel hex loader and more.

SYSMON65 has been tested on a N65C02 hardware. It also includes code for an LCD 16x2 module. The software currently takes just over 3.2KB of memory space.

Pre-requisites & Notes

- *SYSMON65* has been designed for the *Rockwell 65C02* CPU.
- Terminal running ANSI screen codes with serial 19200 baud N81.
- 6551 ACIA routines are bug free, i.e. does not include the Xmit bug
- I use *RealTerm* https://sourceforge.net/projects/realterm/
- Assembled using *Michael Kowalski* (minimum version 1.3.2)

Intel Hex Loader

Intel Hex Loader functionality has been built in.

The command line will look for a semicolon (:) as the first character and will automatically download the file.

Simply paste the intel hex file contents to the command line.

Example Code

SYSMON65 is designed to allow copy & paste from an external text application, e.g., Windows Notepad. Then simply compiling the pasted code with the “S” key.

Copy & paste the sample below (i.e., between the lines)

```
      AUTO

WRBYTE      .EQ $FFDC
ECHO        .EQ $FFEF
CR          .EQ $0D
SP          .EQ $20
;-----------------------------
START       JSR HELLO  ;output to screen
            JSR COUNT
            RTS
;-----------------------------
HELLO       LDX #0
.1          LDA .3,X
            BPL .2
            JSR ECHO
            INX
            BNE .1
.2          ORA #1000.0000
            JMP ECHO
.3
;-----------------------------
      .AT -/HELLO WORLD/
;-----------------------------
COUNT       JSR .2
            LDX #0
.1          TXA
            JSR WRBYTE
            LDA #" "
            JSR ECHO
            INX
            CPX #10
            BCC .1
.2          LDA #CR
            JMP ECHO
```

Command

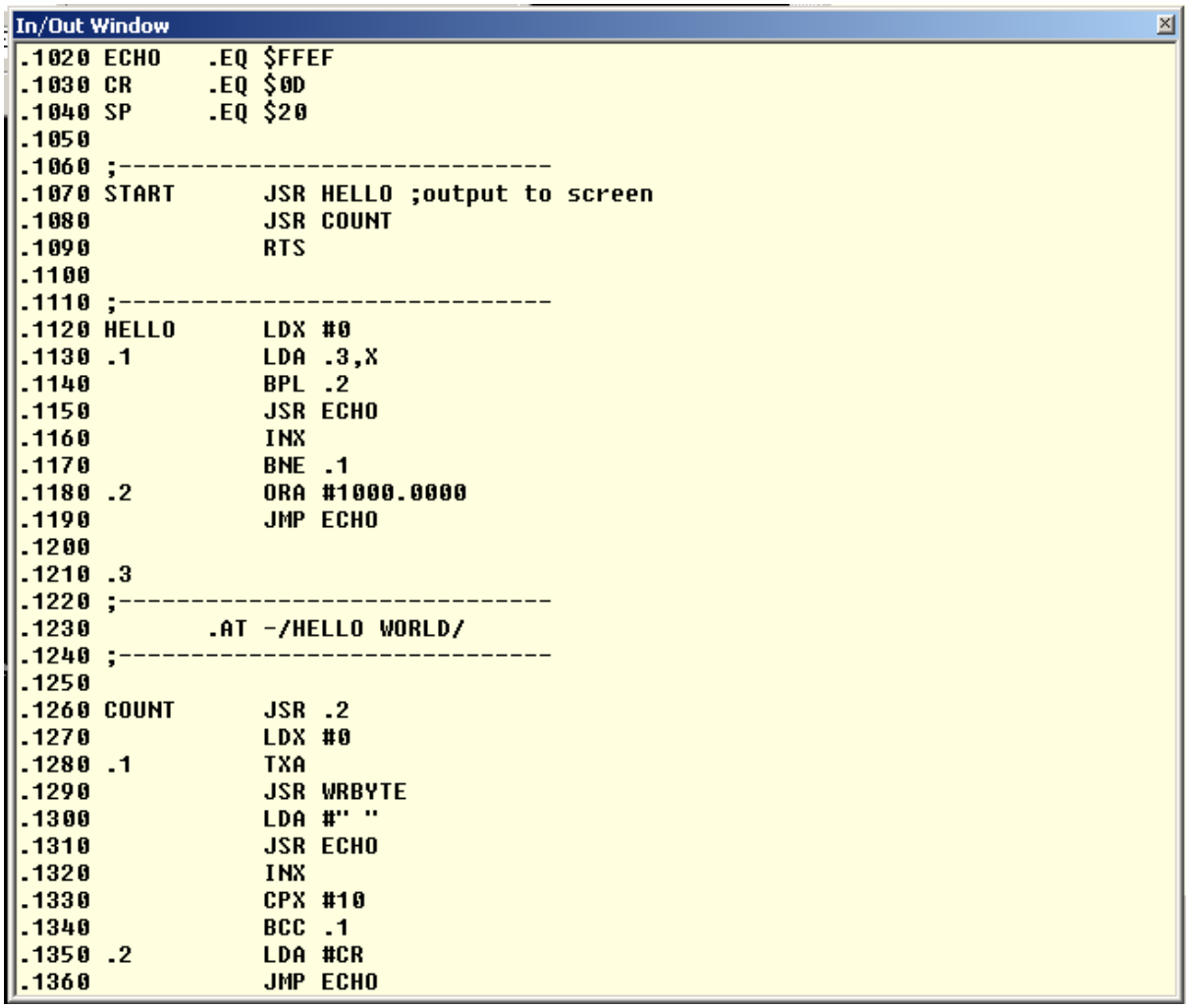
The following section contains the valid commands of the monitor.

AUTO (A)

AUTO linenum,increment

This command will auto number each line. The assembler uses line numbers to allow you to identify which line you like to maintain, i.e., delete, insert, re-number etc. Pressing the [Escape] key on the last line will exit the assembler editor.

Note, the origin of the source is defined by the variable DEF_ORG (default is $1000) and the incremental steps are DEF_INC (default is 10). Also, the count is set by DEF_AUTO – which is 1000



If no operand(s) are specified, then auto line numbering will commence from the last entered line number + current increment. If no line has been entered prior, then auto line numbering will commence from line number 1000, with an increment value of 10.

You may use *linenum* to start auto line numbering from any specified number.
You may use *increment* to change the default increment of 10.

```
AUTO            Start numbering from last entered line number + increment
AUTO 2000       Start numbering from 2000 with unchanged increment
AUTO 4000,5     Start numbering from 4000 with 5 as increment
AUTO ,10        Start numbering from last entered line number + 5 as new
increment
```

Pressing the [Escape] key will cancel auto line numbering and the current unfinished line. Simply press the [Escape] key when you have completed entering your source code or when you have made a syntax error and cannot correct with the [Backspace] key. Typing AUTO again will generate the same line number you had just cancelled to allow you to start again with this line.

You do not have to use AUTO line numbering if you only want to enter a few lines somewhere in your code. Simply type the appropriate line number after the prompt followed by your source text.

The value of *increment* is limited to within the range of 1 to 255. Higher values are truncated to the LSB value only, which could cause some unexpected increments. An *increment* of 0 will result in an increment of 1.

Copy (C)

COPY source,destination,length

This command can be used to copy a part of memory to another destination. Please note, all three parameters are mandatory!

It is possible that the destination block will eventually overwrite the source block. This means that the original block can be partially destroyed after the copy. However, the copy will always be an exact copy of the original contents of the source block.

Warning! Be careful when the destination is specified in page 0. The COPY command utilises 6 bytes in page 0 as temporary storage. Overwriting these values will very likely crash your system. You should also be aware that the input buffer may partially overwrite your copied code if the destination is in the zero page.

There is absolutely no safeguard built into this command. You can make a copy anywhere in RAM, effectively destroying the data which is overwritten. This might even be your precious source text!

This command can be useful if you assembled a program with a different target address (Refer to the *.TA* directive). After assembling your code, you can move the code to the desired destination.

LIST (L)

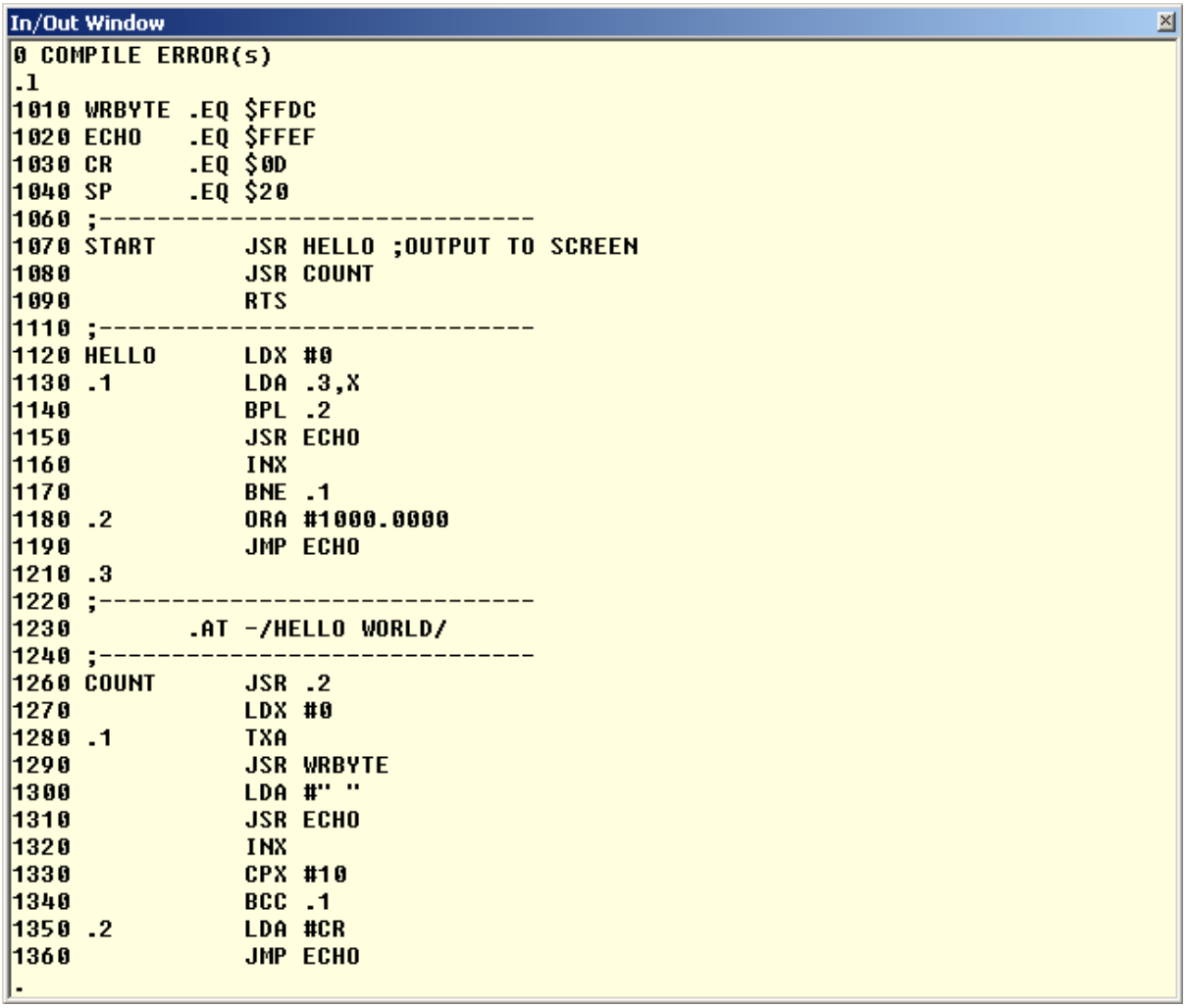
LIST begin,end

This command lists your source to the screen. If no parameters are specified, then the entire program is listed. The *begin* and *end* parameters can be used in the usual manner to control the range to be listed.

```
LIST                    list entire program
LIST 1000               list only line 1000
LIST 1000,2000          list lines 1000 until 2000
LIST 1000,              list from line 1000 until the end of source
LIST ,2000              list from begin of source to line 2000
LIST D                  list dump the entire program
```

The [Escape] key aborts the listing.

The LIST command has an additional feature. Typing LIST D will dump the entire program to the output without line numbers. This option can be used to transfer your source file to the PC over the RS232 connection. The resulting file on the PC may then be saved.



Fill (F)

Fill begin,end,value

Fill a location from source to destination with specified value.

{Status: Bug found!}

Hunt (H) future

Hunt begin, end, value

Hunt for the specified value within the start to end range in memory.

{Status: Feature not complete!}

Memory (Y)

Y lomem, himem

This command can be used to examine or change the memory configuration.

With no parameters this command will show you the current **Lower Limit** (LOMEM), **Total RAM,** and the end of the source address. Your source file starts at address Lower Limit and may extend almost to address **UPPER Spent** (HIMEM). The end of your source file is at the same time the beginning of the symbol table which is built during pass 1 of the assembly. The symbol table will hold all your label declarations and may grow from the end of the source text all the way up to UPPER Spent.

The following is a rough guide on the memory usage in the symbol table:

1. A global label will occupy 6 bytes in the symbol table
2. A local label will occupy 2 bytes in the symbol table

You can use the MEMORY (Y) command to find out what part of memory to save to file/cassette to store your source text. Lower Limit will be the start address and end of source will be the end address to write.

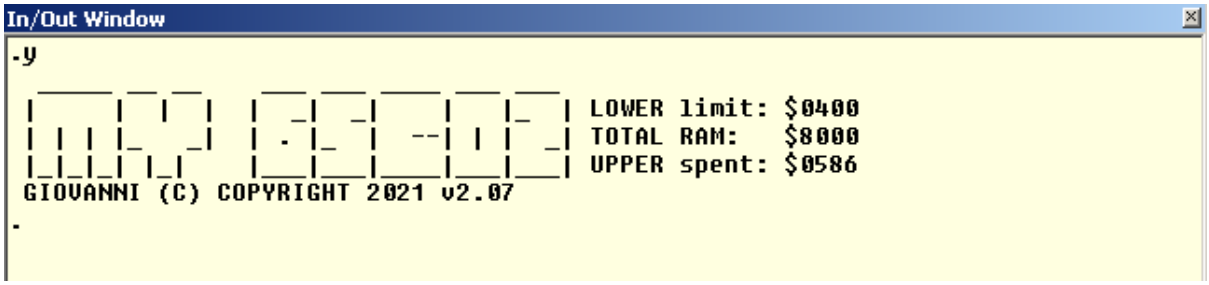
Generated code can be stored from address $0200 up to LOMEM, unless you have set the user safe area which can be set with the zero page addresses USR_OBJLO and USR_OBJHI.

```
Y
0600.$8000      lomem,himem
0F14            end of source text
```

At start up LOMEM will be set to $0600 and HIMEM to the highest available RAM address (max $8000). You can change LOMEM and HIMEM to your desired address values. Sensible values from address $0200 up to the last available RAM. Any other values will probably crash the monitor.

Changing LOMEM and/or HIMEM will delete your current source text!

```
Y $1000,$8000
$1000.$8000
$1000
```



NEW (N)

This command can be used to delete your current source text so that you may start from scratch.

OLD (O)

This command will restore your program if you had previously used the New (N) command.

Please note this command will only work if you have not entered any new source lines after executing the NEW command!

Assemble Code (S)

This command assembles your source code using the 2-pass assembler. If no errors are found, this command will output memory locations of the generated code.

Structure of the generated/output code

Column 1
This column commences after the first space (i.e., behind the line number). This column may contain a label or may be blank.

A global label always commences with a character from A to Z and may contain any number of characters from A to Z, 0 to 9, or dots. Global label definitions may be followed by a colon, which is customary in some assemblers.

A local label always commences with a dot, followed by a decimal number from 0 to 99.

If the first column does not contain a label then it must commence with a space.

A line may commence with a semi-colon in this column which indicates the rest of the line is a comment. Comments are ignored by the assembler.

```
1000 LABEL
1010 ECHO:
1020 .59
1030 LABEL.WITH.A.VERY.LONG.NAME
1040 ; THIS LINE CONTAINS A COMMENT
1050 ; COMMENT LINES ARE IGNORED BY
1060 ; THE ASSEMBLER
1070  NOP       NO LABEL ON THIS LINE
```

If the first character is a space then this column is considered empty, and thus no label exists – refer to line 1070. (Please note, this would make 2 spaces if you also count the space which always follows the line number).

Per default a label gets the value of the current program counter. Only global labels may get a different value if the source line contains an *.EQ* directive.

Please note that global labels may contain virtually any number of characters (from 1, up to the maximum line length). All these characters are significant!

To preserve memory, please keep your labels as short as possible but also ensure they are meaningful. Every character is one byte of valuable memory for each reference to that label!

If your source text contains errors, then the line numbers of the offending lines are listed, followed by a short description of the error. No code will be generated if errors occur during pass 1. Code generated in pass 2 will not be reliable if any errors occur during the assembly process.

```
.s

--------------------------------------------------
.ORG ->$1000.$103A

--------------------------------------------------
0 COMPILE ERROR(s)
.
```

Compiling Errors will show you which lines have errored on.

```
.s

--------------------------------------------------
1130   ERROR
1150   ERROR

--------------------------------------------------
2 COMPILE ERROR(s)
.
```

Column 2

This column starts at least one space behind the first column. It contains either an assembler directive or a mnemonic.

An assembler directive always starts with a dot, followed by 2 characters – refer to the Directives section. A mnemonic always consists of 3 characters.

This column may also start with a semicolon, which means that the rest of the line contains comments only.

If this column is left empty, then the rest of this line must remain empty. It is syntactically legal to place a single label only on a source code line.

```
1000 START ; THE PROGRAM STARTS HERE
1010       INX
1020 .1    RTS
1030 TEXT
1040       .AS -/HELLO/
```

Column 3

This column starts at least one space behind the second column. It contains the operand (if one is required) of the mnemonic or assembler directive specified in Column 2. If the

previous mnemonic or assembler directive did not require an operand, then this column is simply regarded as a comment.

Some mnemonics have an optional operand, e.g., the ROL instruction. Without an operand it rolls the contents of the Accumulator. With an operand it rolls the contents of the address indicated by the operand.

In such cases you will have to use a semi-colon as a comment delimiter.

```
1000      ROL
1010      ROL MEMORY
1020      ROL        ;THIS IS A COMMENT
1030      ROL ; OR COMMENT LIKE THIS
```

c

Break (B)

This command will execute the BRK software interrupt. It is known that you can use the BRK as a software interrupt with the second byte following BRK the command.

Clear Screen (z)

This command will clear the screen via ANSI screen codes sent to the terminal.

Help (?)

This command will display the help screen.

Go (G)

G *address or label*

This command will execute the code specified at the *address* or the *label*.

Erase Line (E)

Erase begin,end

This command will delete multiple lines at a time. Be careful as undo is not possible. Once deleted, these lines are gone forever!

Both the *begin* and *end* parameters are optional. But one of these parameters are mandatory and will have to be specified, for safety reasons.

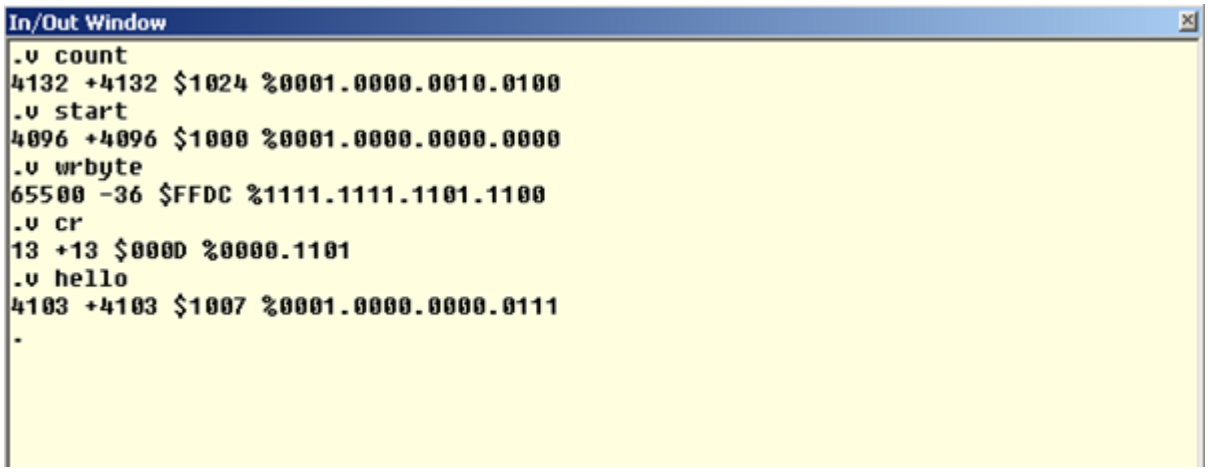
```
ERASE 2000             delete only line 2000
ERASE 2000,2300        delete lines from line 2000 to 2300
ERASE 2000,            delete from line 2000 until the end of source
ERASE,2300             delete from begin of source to line 2300
```

Value (V)

VALUE expression,expression

This command can be used to view the value of labels, convert numbers from one radix to another, or do simple calculations. Label values are only valid after a successful assembly run.

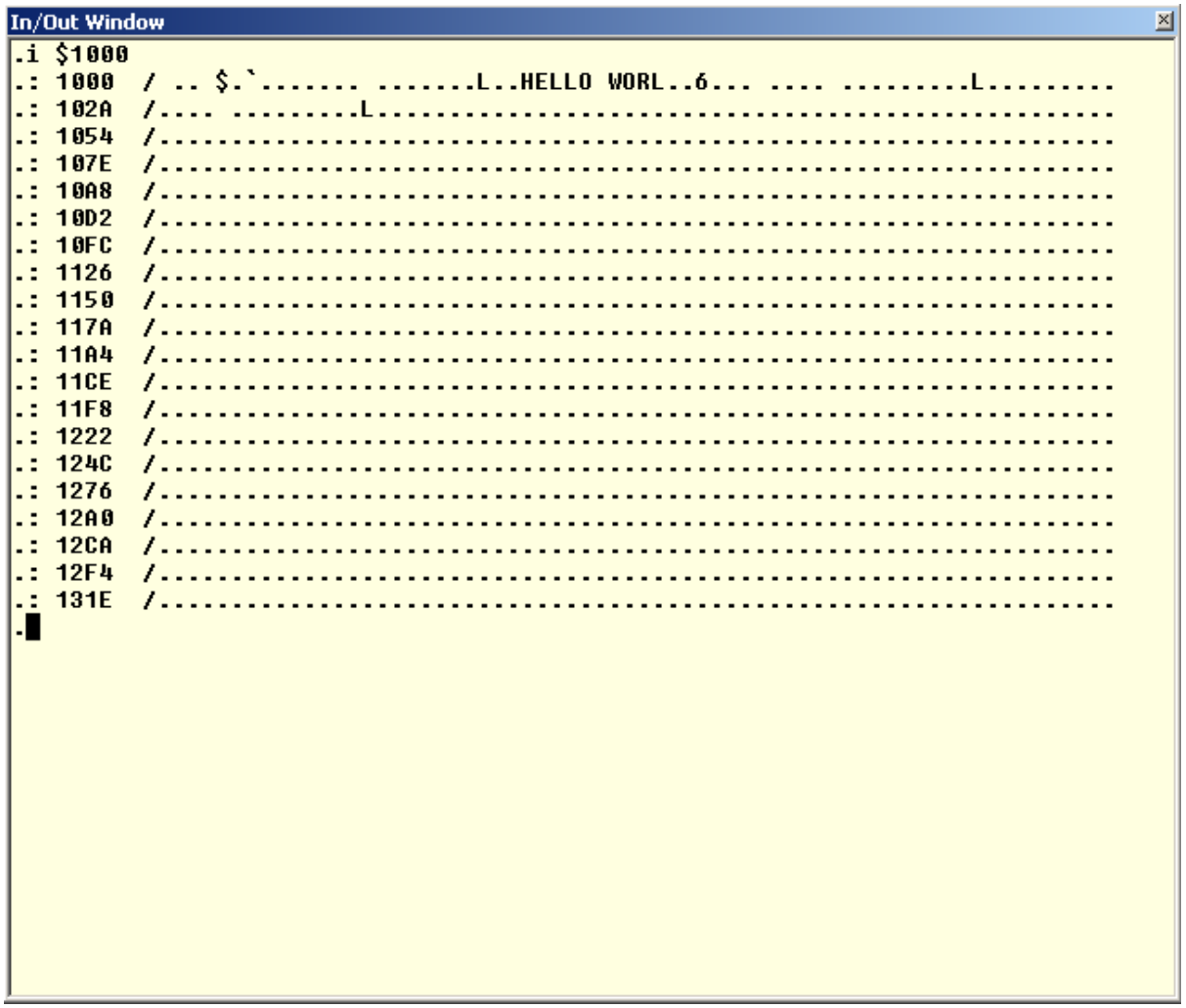
```
VALUE $1234
4660 +4660 $1234 %0001.0010.0011.0100

VALUE -1
65535 -1 $FFFF %1111.1111.1111.1111

VALUE $1234+135
4795 +4795 $12BB %0001.0010.1011.1011

VALUE ECHO
65519 -17 $FFEF %1111.1111.1110.1111

VALUE $1234,1234,%0101.1010
4660 +4660 $1234 %0001.0010.0011.0100
1234 +1234 $04D2 %0000.0100.1101.0010
90 +90 $005A %0101.1010
```



Ascii (I)

i *address*

This command will do an Ascii dump of the specified address. Address values with the $ symbol is considered a hexadecimal value.



User Command (@)

@ command

This command allows the users to extend the commands to the monitor. Changing the USERKEYDEF vector will mean that you can add commands to the keyboard input.

E.g., @ command will jump to USERKEYDEF where the user then needs to parse the IN keyboard buffer for addition keys/commands.

E.g., @S command will jump to USERKEYDEF {aka *JMP (USERKEYDEF)* } where your routine would parse the IN for S and then act accordingly.

See routine KEYDEF for example of how current commands are parsed.

Renumber *(R)*

RENUMBER from,first,increment

From time to time you may want to renumber your source, or part of your source. Usually you want to do that to tidy up a bit, or to make room for more than a few new source lines between two other lines. For that purpose you can use the RENUMBER command.

The *from* parameter determines the line from which to start renumbering. If you omit it you will renumber your entire program.

first will be the first new line number to be used for the renumbered part of your source. If this line number is omitted the default AUTO line number will be used (1000). Finally the *increment* parameter will determine the increment of the renumbered part of your source. If it is omitted the default increment of 10 will be used. The valid range for *increment* is from 1 to 255.

You can't set *from* higher than *first*, otherwise you may get duplicate line numbers which would definitely confuse the editor.

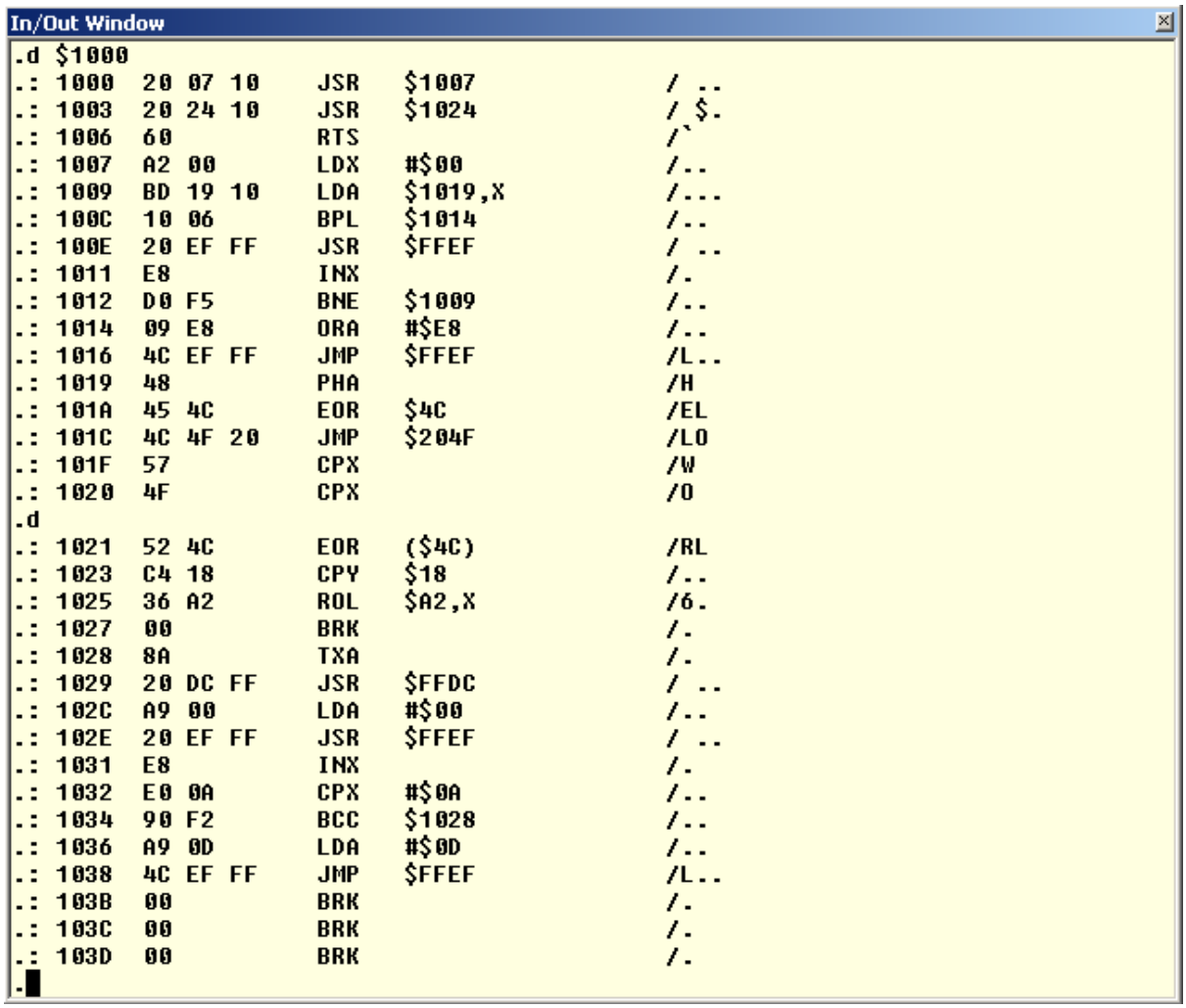
After renumbering the next auto line number will be the last renumbered line number + increment. The new increment will also be set according to the renumbered increment.

```
RENUMBER               renumbers entire source, same as RENUMBER 0,1000,10
RENUMBER 2000,3000     renumbers source from 2000 until end, increment 10
RENUMBER ,4000         renumbers entire source, new source starts at 4000
RENUMBER 1000,2000,5   renumbers from line 2000, new line 2000, increment 5
```

Disassembler (D)

D address (or label)

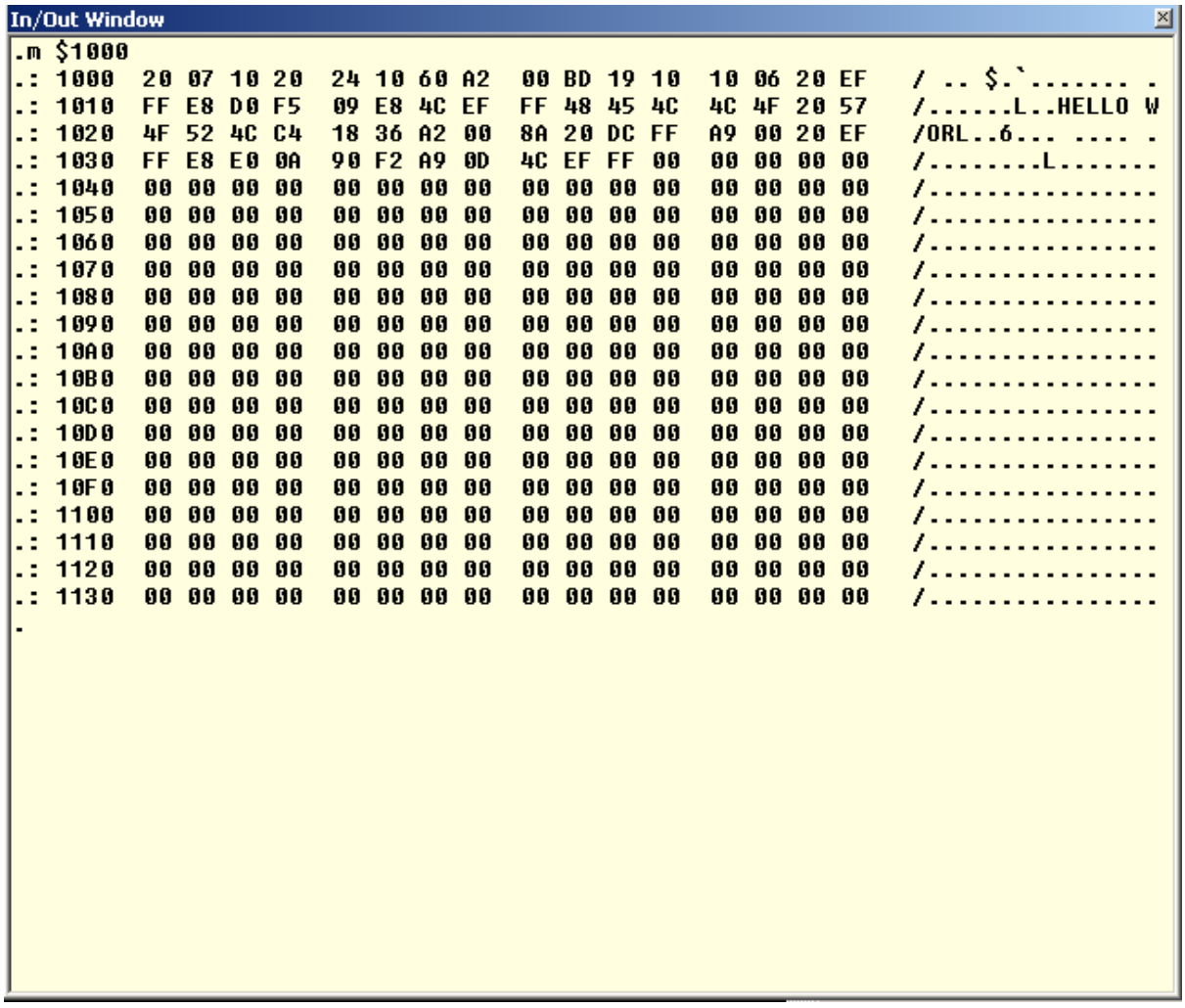
This will dissemble code from start address or from label. When just press d will continue down one page.



Mem Dump (M)

M *address*

Byte and asci dump of ram. Consecutive M , will continue page through the memory.

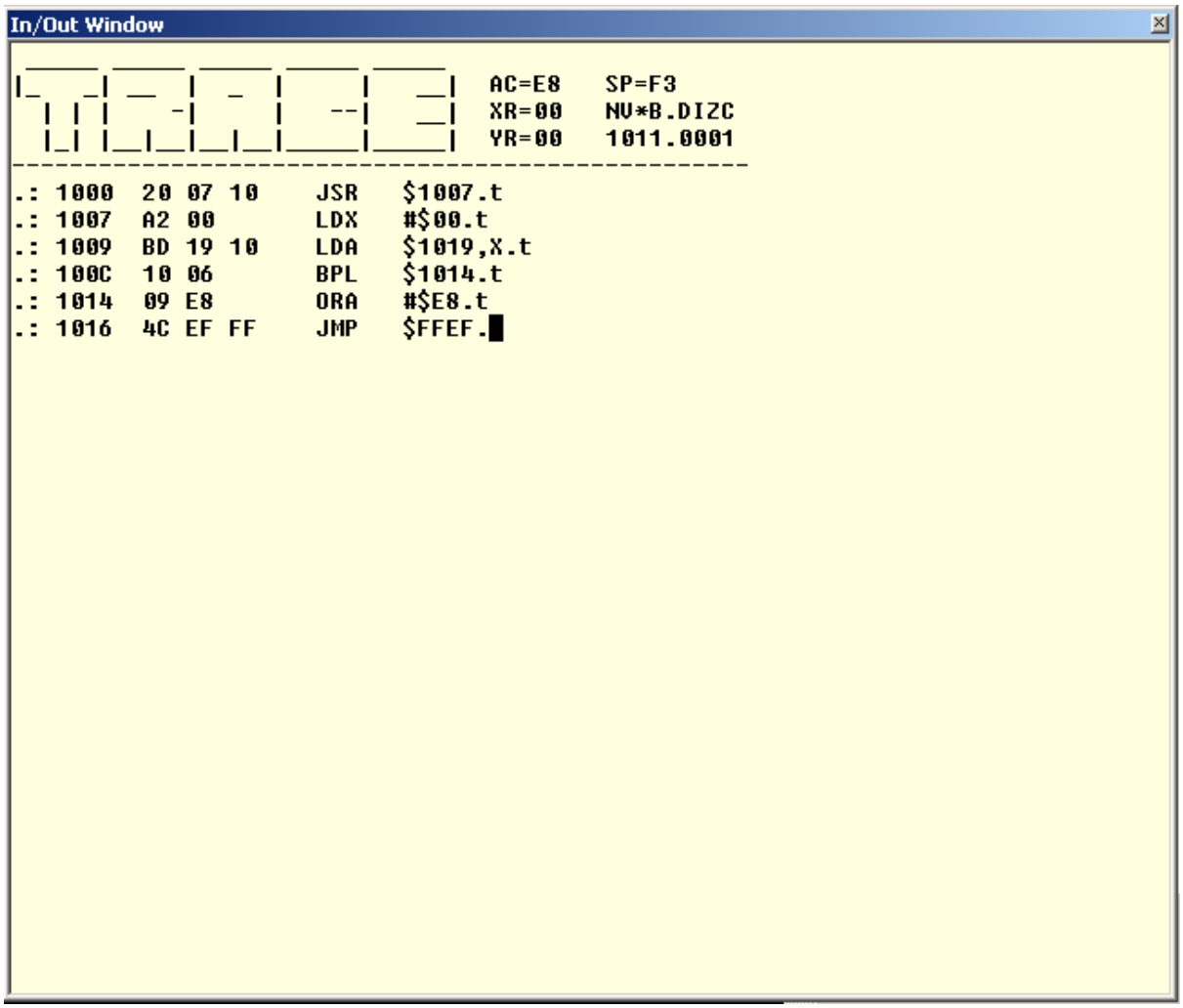


Trace (T)

T *address*

This is steps through the code one line at time. Pressing **t** will continue to step through each line. The flags, PC, registers show the values of the last actioned command.

```
TRACE                   Continues tracing from last address
TRACE $2000             Trace from memory hex location $2000
TRACE start             Trace from label start
```



Directives

Directives are often called pseudo-opcodes. They are always to be found in column 2, where you would also find processor opcodes (mnemonics). A directive is a command to the assembler, for instance to generate data bytes or change the current program counter.

The following section contains valid directives of the monitor.

.AS -/string/

This directive allows you to enter an entire string as data into your program. If the first character of the operand is — sign the entire string will be in negative ASCII (128 .. 256), the way the Apple 1 likes to get its ASCII characters. If the first character is not a — sign the string will be in positive ASCII (0 .. 127).

The string of characters must be surrounded by a so called delimiter. A delimiter can be virtually any ASCII character, which should be the same at the beginning and at the end of the string. Usually the characters / \ " or ' are used as delimiters, that is if you can type \ of course. The delimiter you use may not occur in the string, otherwise you'll get an error message.

```
1000    .AS /ABC/          generates 41 42 43
1010    .AS !123!          generates 31 32 33
1020    .AS -"ABC"         generates C1 C2 C3
1030    .AS -'1234567890'  generates B1 B2 ... B3 B0
```

Please note that the Assembler does not allow you to use more than one operand after

.AT -/string/

This directive is almost identical to the .AS directive. The only difference is the polarity of the last generated character, which is opposite from the rest of the string. This opposite polarity can be used by the software to signal the end of the string to be printed.

```
1000    .AT /ABC/           generates 41 42 C3
1010    .AT !123!           generates 31 32 B3
1020    .AT -"ABC"          generates C1 C2 43
1030    .AT -'1234567890'   generates B1 B2 ... B3 30
```

.BS expression

This directive skips the number of bytes indicated by the *expression*. Therefore the *expression* may not contain forward referenced labels, otherwise the assembler would not know how many bytes to skip.

Skipped bytes are not altered! The only thing that happens is that the current program counter is incremented by *expression*.

You can use .BS for instance to declare RAM addresses easily (like i.e. Zero Page locations).

```
1000          .OR $0080
1010 POINTER .BS 2    A 2 BYTE POINTER
1020 COUNT   .BS 1    A 1 BYTE COUNTER
1030 BUFFER  .BS 10   A 10 BYTE BUFFER
1040 FLAG    .BS 1    A 1 BYTE FLAG
```

You may use any value as *expression*, even quite silly values like $FFFF, the assembler couldn't care less.

.DA *expression*

With this directive you can include data bytes and words into your program. You can include as many operands as you like (until the program line is full), all separated from the previous one by a comma. Any combination of word, LSB and MSB operands is possible.

For byte data the *expression* must be preceded by a < or a > symbol. The < symbol will use only the LSB of the 16-bit *expression*, whereas the > symbol will use the MSB. Word data is generated with LSB first (little endian). This is the way the 6502 likes it best.

```
1000    .DA $1234                 generates 2 bytes, 34 12
1010    .DA >$1234                generates 1 byte, 34
1020    .DA <$1234                generates 1 byte, 12
1030    .DA $1234,<$5678,>$9ABC   multiple operands, 34 12, 78, 9A
```

The data directive (.DA) and all immediate addressing mode instructions normally use the < symbol to identify the 8 least significant bits of the expression. If you need the most significant bits however you can substitute the <symbol by the >symbol.

```
    .DA $1234     16-Bit data result ($34 $12)
    .DA <$1234    8-Bit data result LSB ($34)
    .DA >$1234    8-Bit data result MSB ($12)
    LDA <$1234    Load Accu with LSB ($34)
    LDX >$1234    Load X with MSB ($12)
```

.EQ expression

Normally a label will get the value of the Program Counter at the beginning of the line on which the label is assigned. This behaviour can only be changed by this directive. Column 1 must contain a global label when the second column contains the .EQ directive. You can't use the .EQ directive on local labels.

The label in column 1 gets the value which is represented by *expression*. This *expression* may not contain forward referenced labels!

```
PRBYTE .EQ $FFDC
ECHO   .EQ $FFEF
CR     .EQ $8D
SPACE  .EQ " "
CHOUT  .EQ ECHO     CHOUT will get the value $FFEF
```

It doesn't matter what type of data is assigned to a label. It may be an address, a constant value, an ASCII value, or whatever. You can however only assign values to labels. This means that you cannot assign a string of characters to a label.

.OR expression

This directive sets the starting address of your program, or parts of it. It also sets the target address to the same value (See .TA directive). If this directive is omitted the default starting address will be $1000. See DEF_ORG in Constants.65s

You can set the starting address *expression* anywhere in memory. However you can not store code just about anywhere in memory. If you haven't set a user safe area you can only generate code to the range from $0200 (DEF_OBJLOW) to LOMEM, otherwise you'll get a memory error.

You may change the starting address of your program as often as you like. Every block of memory generated is reported by the assembler, which makes it easier for you to locate your code.

The *expression* may not contain forward referenced labels.

```
1000       .OR $0080    ;START ZP DEFINITION
1010 PNTR  .BS 2
1020 CNTR  .BS 1
1030 BFFR  .BS 10
1040       .OR $0300    ;START CODE HERE
1050       NOP
1060       NOP
1070       .OR $0400    ;MORE CODE HERE
1080       NOP
1090       NOP
1100       NOP
```

(.BS directive does not generate code)

```
.s

-------------------------------------------------
.ORG ->$0080.$008C
.ORG ->$0300.$0301
.ORG ->$0400.$0402

-------------------------------------------------
0 COMPILE ERROR(s)
.
```

.TA expression

You can't generate code in protected memory. Normally you can only generate code from address $0200 until LOMEM, the rest of memory is protected.

You may indicate a user safe area by setting the memory addresses USR_OBJLO and USR_OBJHI to declare another part of memory to be safe. However you're in charge there, you're the one who should be absolutely sure that it IS safe! Setting these two values doesn't automatically make the area safe, it only allows the assembler to store generated code there.

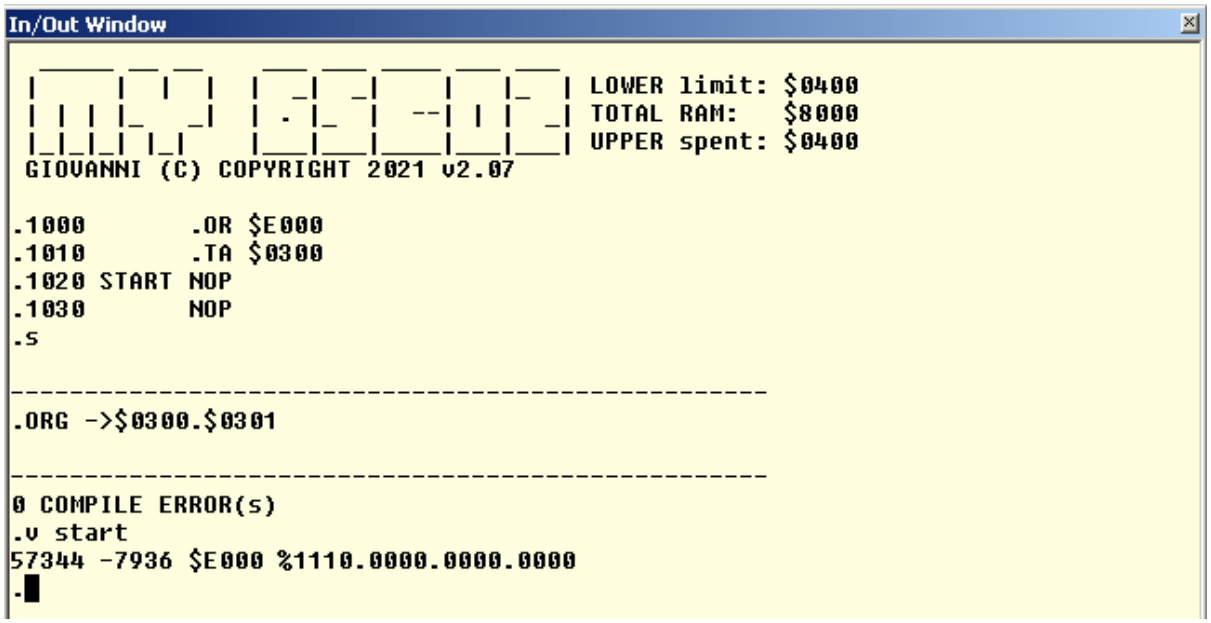
But what if you want to create a program which should run in a protected area, let's say from address $E000? Simple, you set the .OR to $E000, and change the target address to a safe area, e.g. $0300 (see example below).

The assembler will generate all addresses as if it was actually using address $E000. However the code is stored at address $0300. Obviously this will result in a program which does not work as is. You'll have to move the program to the intended destination before it can be run.

Moving the code to its final destination can be done with the COPY (C) command, or by saving it to file and loading it at a different address.

The *expression* may not contain forward referenced labels.

```
1000            .OR $E000
1010            .TA $0300
1020 START      NOP
1030            NOP

START
------------------------------------------------------------
ORG -> $0300.$0301     this proves that the right target address is used
------------------------------------------------------------
0 COMPLIE ERRORS

VALUE START             here's some more proof
57344 -8192 $E000 %1110.0000.0000.0000
```


In/Out Window
LOWER limit: $0400
TOTAL RAM: $8000
UPPER spent: $0400
GIOVANNI (C) COPYRIGHT 2021 v2.07
.1000 .OR $E000
.1010 .TA $0300
.1020 START NOP
.1030 NOP
.s
.ORG ->$0300.$0301
0 COMPILE ERROR(s)
.v start
57344 -7936 $E000 %1110.0000.0000.0000
.

.DB expression

{Not implemented yet}

Single byte definition.

Numbers and Expressions

Many commands and operands accept numbers and expressions. An expression is simply a mathematical combination of several numbers.
Any number is limited to 16-bits only. Enter larger numbers than that and you'll be treated with a range error.
You may precede any number with a negative sign to make it negative (2's compliment).

Wherever the Assembler expects a number you can supply it in one of the following options:

Decimal numbers

Start with a digit from 0 to 9, and may only contain these numbers.

```
123
-500
```

Hexadecimal numbers

Start with a dollar symbol, and contains only normal digits 0 to 9 and extra digits A to F.

```
$10
$FFEF
-$100
```

Binary numbers

Start with a percent symbol and may contain only the digits 0 and 1. You may place dots anywhere in a binary number to make them easier to read. The assembler simply ignores the dots.

```
%1000.1101
%1111100101110101
%1111.1001.0111.0101    same value as above!
-%1000
```

Positive ASCII

Generates values between 0 and 127, depending on the character enclosed in single quotes.

```
'A'    TRANSLATES TO $41
'2'    TRANSLATES TO $32
```

Negative ASCII

Generates values between 128 and 255, depending on the character enclosed in double quotes. Please note that this is the native Apple 1 mode to represent ASCII characters!

```
"A"     TRANSLATES TO $C1
"3"     TRANSLATES TO $B3
```

Current PC

A single dollar symbol, not followed by a legal hexadecimal digit, will result in the current program counter value. The value used was the program counter at the start of the current source line.

```
$
```

Labels

Simply the label's value is used. Only assembly pass 1 allows the use of labels which are not defined yet. In that case we speak of forward referenced labels.

An undefined label during pass 2 of the assembly will result in a definition error.

In case of forward referenced labels we can not know their actual value during pass 1 of the assembler. Therefore some instructions which can use shorter addressing modes will fall back on the worst case scenario and use long addressing mode instead.

Expressions can be used to combine 2 or more values to get a new final value. You can use one of the 4 basic operators in expressions:

+ Addition

- Subtraction

* Multiplication

/ Division

All expressions are evaluated from left to right. No priority is given to multiplication and division over addition and subtraction unlike in normal math. Parentheses can not be used to change priority in expressions. Overflows in expressions are ignored and the result is always truncated to 16-bit integers.
You can mix any legal number form with any number of operations.

```
1234+$1200    RESULTS IN $16D2
$F000-123     RESULTS IN $EF85
%101*2        RESULTS IN $000A
$5678/4       RESULTS IN $159E
LABEL*2       RESULTS IN THE VALUE OF LABEL TIMES 2
```

All results are 16-bits long integers. No errors are reported if the result exceeds the limits of a 16-bit number, only the least significant 16-bits are used as result. This may sometimes give some strange results, especially if the expression contains multiple operations.

For example 7/8*100 results in 0. This is because 7/8 is 0.875, which is truncated to 0 caused by the integer division. You'll get a much better result by rewriting the expression to 100*7/8, which is still an integer.

Interrupts

Interrupts pass though RAM vectors to allowing you change the locations.

```
USIRQ       .RS   2          ;User IRQ vector

USBRK       .RS   2          ;User BRK vector

USMNI       .RS   2          ;User NMI vector
```

Break Vector

Change USBRK to point to your routine. Then return back to BRK_RETURN routine. Otherwise ensure you have below to mirror the initial 3 push when the IRQ/BRK was called.

```
PLP         ;pull off flags
PLA         ;PC low
PLA         ;PC high
```

```
USBRK       .RS   2          ;User BRK vector
```

IRQ Vector

Change USBRK to point to your routine. Then return back to BRK_RETURN routine. Otherwise ensure you have below to mirror the initial 3 push when the IRQ/BRK was called.

```
PLP         ;pull off flags
PLA         ;PC low
PLA         ;PC high
```

Reset Vector

This can be changed. Ensure that the new vector has a CRC that's EOR with $A5

```
USRRS       .RS   3          ;User RESET vector

LDA   #<YOUR_RESET           ;your reset user vector
STA   USRRST                 ;store in RAM
EOR   #$A5
STA   USRRST+2
LDA   #>YOUR_RESET
```

```
      STA   USRRST+1              ;press reset
```

Note: RESET_RETURN will reset the IRQ,NMI and IRQ vectors.