

# **Fast Assembler**

## **for SpartaDOS X**

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# Introduction

Fast Assembler is a file to file assembler for SpartaDOS X. The assembler can generate object files and executable files for SpartaDOS X and Atari DOS. The source text must be available in ATASCII files.

The assembler has the following features:

- Support of SpartaDOS X and Atari DOS object files
- Support of relocatable SpartaDOS X blocks
- Support of SpartaDOS X symbols
- The maximum file length of the source code and object data only depends on the file system, as it is a real file to file assembler

Fast Assembler is fully compatible with Quick Assembler, but is not compatible with MAC / 65 or Atari Assembler Editor. The Fast Assembler syntax is supported by MADS the 6502 cross assembler. MADS is available for macOS, Linux and Windows.

The Fast Assembler package contains the following files and directories:

## FA.COM

This is the executable file in SpartaDOS X format. This is the only file needed to start the assembler. This file can be copied into a directory, which is contained in \$PATH, in order to be able to start the assembler easily from all directories.

## FA.MAN

This is the manual page for Fast Assembler (see SpartaDOS X instruction MAN). The most important information is summarized here for your reference. This file should be copied into a directory which is contained in \$MAN.

## EXAMPLES>

This directory contains well-commented examples.

## DOCS>

This directory contains documentation in Atari format.

## SOURCES>

This directory contains the source code for Fast Assembler. Fast Assembler can assemble itself and can thus be further developed under SpartaDOS X.

## TEST>

This directory contains a test environment. It contains the batch file TEST.BAT to start the tests. The EXAMPLES and SOURCES directories are also required for all tests.

# Calling Syntax

```
FA src[.ext] [dst[.ext]] [/L|S|E]
```

The source file `src[.ext]` is assembled and the result is saved as an object file `dst[.ext]`. The standard extensions are `.ASM` and `.OBJ`. However, others can be used. The drive and path are taken from the location where the assembler was called.

With the `/ L` option, all program lines are output during assembly. The lines are output as the assembler reads them, i.e. all includes are resolved and the line numbers are assigned consecutively.

With the / S option, a summary is output at the end of the assembly, e.g. total number of labels, blocks and memories. The memory is output in the following format:

Memory: \$code-\$stat\_mem-\$stat\_end \$dyn\_mem-\$dyn\_end

%code is the address to which the assembler was loaded (MEMLO at the time the assembler was started). The start of the static buffers, e.g. for line processing and file access, is specified with \$stat\_mem and the end with \$stat\_end. The dynamic buffers, e.g. for the symbol table, start at \$dyn\_mem (MEMLO at the time the assembly is started) and end at \$dyn\_end. This can be used to check how much memory was used during assembly. If \$dyn\_end reaches the value of MEMTOP (see SpartaDOS X command MEM), an error occurs: Out of Memory.

The /E option converts assembly language errors to SpartaDOS X errors beginning with 224 (\$ E0) if errors occur during assembly. This can be used in batch processing with IF ERROR (see section Error Messages at the end of the document).

## Examples

### Atari DOS Programm - RAINBOW.ASM

This example shows how Atari DOS programs can be created. It's a little demo with classic color scrolling.

Assemble with:

```
FA RAINBOW.ASM RAINBOW.COM
```

Execute with:

```
RAINBOW
```

The program is ended with START.

The program consists of two blocks. One block contains the actual program, the second the start address for automatic start. A classic Atari DOS program. Blocks are introduced with the pseudo instruction **blk** (see section Pseudo instructions). The second parameter contains the type. DOS stands for Atari DOS Block. The third parameter is the start address of the block. The instruction `blk DOS $ 3000` corresponds to the instruction `ORG $3000` or `*=$3000` in other assemblers.

```

* Example for FA
* Demo Atari Rainbow Color
* Atari DOS executable
* press START to end

RTCLK    equ $14
RUNAD    equ $02e0
COLPF2   equ $d018
CONSOL   equ $d01f
WSYNC    equ $d40a
VCOUNT   equ $d40b

* main program Atari DOS block
      blk DOS $3000
* reset console keys
start  lda #$08
      sta CONSOL
loop   clc
* calc next color
      lda VCOUNT
      adc RTCLK
* wait for sync
      sta WSYNC
* set color
      sta COLPF2
* check START
      lda CONSOL
      and #$01
      bne loop
      rts

* run address Atari DOS block
      blk DOS RUNAD
      dta a(start)

      end

```

## SpartaDOS X Program - HELLO.ASM

This is an example of a SpartaDOS X program. It cannot be run under Atari DOS. This example uses relocatable blocks and symbols.

Assemble with:

```
FA HELLO.ASM HELLO.COM
```

Execute with:

```
HELLO
```

After entering a name e.g. Holger, it says hello:

```
Hello Holger !
```

The SpartaDOS symbols PRINTF and GETS are used. These symbols are resolved when the program is started. They are called with JSR and await parameters immediately afterwards. If you make a mistake with the name of the symbol, you will get a runtime error.

Example, change this line:

```
PRINTF    smb 'PRINTF'
```

To this line:

```
PRINTF    smb 'PRINTFX'
```

The program can be assembled, but when started under SpartaDOS X the following error message is output:

```
Symbol PRINTFX
154 Symbol not defined
```

More information about the symbols can be found in the “SpartaDOS X Programming Guide”.

The program consists of two blocks, a relocatable block (reloc block) and a memory-reserving block (empty block). Both have in common that the loading address is not known at the time of assembly. Such blocks are always automatically loaded from MEMLO by SpartaDOS X and MEMLO is then incremented. The addresses in the program are then also adapted. For the empty block, SpartaDOS X only continues to set MEMLO, i.e. the memory is not initialized. After the end of the program, SpartaDOS X will reset MEMLO.

```

* Example for FA
* Hello from Atari
* SpartaDOS X executable with
* relocatable code

* used SpartaDOS X symbols
* see SDX programming guide
PRINTF    smb 'PRINTF'
GETS      smb 'GETS'

* name buffer size
nam_siz equ $40

* relocatable code block
        blk reloc main
* print question
        jsr PRINTF
        dta c'What''s your name?'
        dta b($9B,$00)
* get name, due to code
* relocatability you cannot use
* lda <name and ldx >name because at
* compile time we do not know where
* the program will be located!
        lda namev
        ldX namev+1
        ldy #nam_siz
        jsr GETS
* print greetings
        jsr PRINTF
        dta c'Hello %s !'
        dta b($9b,$00)
        dta v(name)
        rts
* vector is needed for get name
namev    dta v(name)

* relocatable data block
* program counter is incremented!
* by BLK EMPTY, symbols must be
* defined beforehand
name      equ *
        blk empty nam_siz main

* blocks for address and symbol update
        blk update addresses
        blk update symbols

        end

```

## Memory-resident program - TSR / TSR\_CALL.ASM

In SpartaDOS X it is very easy to write memory-resident programs. These are programs that are not removed from memory when finished.

This can be achieved with the INSTALL symbol. It is initialized with 0 when a program is started. If INSTALL has the value \$ FF when the program is ended, it is not removed from memory, i.e. MEMLO is not reset. This makes it very easy to write additional drivers.

You can also give your subroutines a name and thus define new SpartaDOS X symbols. This is done with the following block command:

```
blk update new <address> '<name>'
```

If the name begins with @, it is also recognized as a command in COMMAND.

This example consists of two programs:

- 1) TSR.ASM defines a new symbol @GREET, which is also known as a command (the name begins with @)
- 2) TSR\_CALL.ASM uses this symbol. For this reason it only works if TSR has been started beforehand and the @GREET symbol is known. If not, the following error occurs:

```
@GREET symbol  
154 Symbol not defined
```

When TSR has been carried out, GREET can be called directly from SpartaDOS X, or the program TSR\_CALL can be called, which calls the symbol.

## Communication between programs - CALLER / CALLEE.ASM

In SpartaDOS X you can directly start another program (CALLEE) from one program (CALLER) with the function U\_LOAD. The FLAG symbol can be used to transfer a value to the called program. There are other ways of transferring data to the called program. To keep the example simple, these are not used here. The called program can set a return value with the STATUS symbol.

The CALLER program calls another program and sets FLAG beforehand. The value for FLAG and the program name are transferred via the command line, e.g.:

```
CALLER 2 CALLEE.COM
```

The CALLEE program reads FLAG, multiplies the value by 8 and sets STATUS with the result. The MUL\_32 function is used for this. This function expects the parameters at certain addresses relative to COMTAB and thus also writes the result.

Both programs output the values of FLAG and STATUS that you have set or received.

## Program to compare files - MY\_COMP.ASM

This example shows how a new external command for SpartaDOS X can be developed. It is similar to the COMP command and compares two files. One difference is that the result is not only output with PRINTF, but also STATUS is set. If the files are not equal then STATUS is set to \$ FF(255). Since this is a value above \$80(128), it is interpreted by SpartaDOS X as an error. Since the error number \$FF(255) has no error text, the following output occurs:

```
255 System ERROR
```

Setting an error number has the advantage that you can respond to it in a batch file with the IF ERROR 255 command. This can be used e.g. for automatic tests if a program to be tested creates a file and the expected result is already available in another file.



## Hardware Fine Scrolling - HSCROL.ASM

This is an example for horizontal fine scrolling. A display list with one GRAPHICS 0 line is defined. This line is scrolled from right to left in an endless loop.

## ANTIC Demo with Display List und Vertical Blank Interrupts - ANTIC.ASM

A display list with six different parts is defined. Only display list and vertical blank interrupts are used to change colors and lines are scrolled using fine scrolling.

## GTIA Demo with Graphic and Noise - GTIA.ASM

The CPU is programmed in parallel to the screen display. The background color and two players are programmed directly via GTIA to produce an animation. Furthermore the sound connection of GTIA is used to produce noise. In 400/800 machines the GTIA is connected to the internal speaker.

## POKEY Demo with Music using Software Timer - POKEY.ASM

This example shows a little frame work to produce music with a maximum of four voices using a software timer of the operation system.

# Structure of the Source Code

The source text is line-oriented. Each line can contain one statement. There may also be blank lines; these must not contain any further spaces. For example, if line 42 contains just spaces, the following error message is generated:

```
42:
ERROR: Unexpected eol
```

Comment lines begin with \*. Everything after \* up to the end of the line is ignored by the assembler. Example:

```
* This is a comment!
```

Comments can also follow an instruction. There they do not have to be introduced with \*. The assembler ignores all characters after an instruction up to the end of the line. An instruction line is structured as follows:

```
[label] opcode [operand] [comment]
```

Example with a label and a comment:

```
start    ldx #$08 set X register
```

Example without label or comment:

```
ldy #$10
```

To use the low or high byte of a value, the operators < and > must be used. Example:

```
lda <my_address
ldy >my_address
```

A special feature compared to other 6502 assemblers are the operations that can be used both with the accumulator and with other types of addressing. In this case the @ sign must be used for the accumulator.

Example operation ASL (Arithmetic Shift Left) at address \$3000:

```
asl $3000
```

Example operation ASL at accumulator:

```
asl @
```

## The Assembly

The assembler processes the source code line by line and in the final pass the object file or executable file is written accordingly. None of the files are kept in memory, i.e. the maximum size of the files that can be processed or created is only limited by the file system. The assembler only keeps the internal symbol table in memory.

The source text is run through at least twice. After each run, the number of identifiers that could not yet be resolved is listed. Sometimes more than two runs have to be carried out, e.g. according to the following definition:

```
a equ b
b equ c
c equ 100
```

In the first pass c is determined, in the second by b and in the third by a. Care should be taken to avoid something like this, as this increases the time for the assembly unnecessarily (due to the number of runs). The following definition can be processed in two passes:

```
c equ 100
b equ c
a equ b
```

The assembler supports a maximum of 8 passes.

The assembler supports includes. The maximum depth of nesting of includes depends on how many files can be opened at the same time. At least two files are opened, for the source and the object file, for each further nesting of includes, a further source file is opened. The number of files that are open at the same time can be configured with the SPARTA driver in CONFIG.SYS. The standard value of SpartaDOS X is 5, i.e. a maximum depth of nesting of 3 is possible.

In the following it is described which expressions can be used and which pseudo-instructions (instructions which do not represent 6502 instructions, but rather are used to control the creation of the object file or the processing of expressions and values).

## Expressions

Text expressions are defined by quotation marks, 'or ". To display quotation marks in a text expression, two consecutive ones must be used, e.g. .:

```
'Windows '95'
```

Numbers in expressions:

- Binary numbers start with %, e.g.:  
%101
- Hexadecimal numbers start with \$, e.g.:  
\$FDAACDE
- Decimal numbers, e.g.:  
23454

The maximum length of numbers is 4 Bytes.

Characters in ATASCII, e.g.:  
'A', or ''' for ' character

Character in internal display code (like in screen memory), e.g.:  
"I" or "" for " character

The length of text expressions is always 1 Byte and the value of the first character is taken, e.g.:  
'A' and 'ABC' return the same value A.

The following operators are supported:

- & – Operator AND
- | – Operator OR
- ^ – Operator EOR
- \* – Multiplication
- / – Division
- + – Addition
- – Subtraction

Sequences of operators are evaluated according to the above-mentioned priorities (AND highest, subtraction lowest). It is always calculated with 4 bytes. A maximum of 32 operators can be used per expression. The priority can be changed within an expression with the square brackets, e.g. :  
[[4+5]\*[256/21]]&\$FF

There are two other special characters. \* and ! return current program counter. \* can only be used at the beginning of an expression, while ! can be used in general e.g. :

```
*+4  
!-22  
$2300+!
```

## Pseudo Instructions

All supported pseudo instructions are described below. At the end of the section, the pseudo instructions are described that are only supported for compatibility with Quick Assembler. These are not required when creating new programs.

### **blk**

This statement declares a new program block. The total number of blocks in a program is limited to 256. The following block types are supported:

#### **blk n[one] a**

A block without a header is declared. The program counter is set to address a.

#### **blk d[os] a**

Declares an Atari DOS block with \$FFFF header or without a header if the program counter is already at a.

## **blk s[parta] a**

Declares a SpartaDOS X block with fixed load address with header \$FFFA, the program counter is set to a.

## **blk r[eloc] m[ain]|e[xtended]**

Declares a relocatable SpartaDOS X block with header \$FFFE in main (m[ain]) or extended memory (e[xtended]).

## **blk e[mpty] a m[ain]|e[xtended]**

Declares a relocatable SpartaDOS X block with header \$FFFE to reserve bytes in main (m[ain]) or extended memory (e[xtended]). The program counter is immediately increased by a.

## **blk u[pdate] s[ymbols]**

Generates a SpartaDOS X block with header \$FFFB, which updates the symbol addresses in Sparta or Reloc blocks.

## **blk u[pdate] a[ddresses]**

Generates a SpartaDOS X block with header \$FFFD, for updating addresses in Reloc blocks.

## **blk u[pdate] n[ew] a text**

Generates a SpartaDOS X block with header \$FFFC, which declares a new symbol in a Reloc block with the address a. If the symbol name is preceded by an @ and the address comes from main memory, such a symbol can be called up via COMMAND.COM.

## **end**

End of the source or include file.

## **label equ a**

Assigns a value to a name. The name can be a maximum of 240.

Example:

RUNAD equ \$02e0

## **[label] dta x(expr)**

Generates data, where x can be defined as follows:

- b(expr) – one Byte

- `a(expr)` – two Bytes, Address
- `v(expr)` – two Bytes, Address, is updated in Reloc blocks, for all others blocks like `a(expr)`
- `e(expr)` – three Bytes
- `f(expr)` – four Bytes
- `g(expr)` – four Bytes in reverse order
- `l(expr)` – lower Byte
- `h(expr)` – higher Byte
- `c'ATASCII'` – Text in ATASCII
- `d'INTERN'` – Text in internal display code

In addition, numeric data can be specified as expressions separated by commas, e.g.:

```
myDat dta e(0,15000,$FFAACC)
      dta b($FF),a($C000)
```

## **icl source[.ext]**

Inserts the source text of a file. The drive and path are taken from the current directory by default where the assembler was started, e.g.:

```
icl 'FAMAIN.ASM'
```

## **label smb text**

Declaration of the use of a SpartaDOS X symbol. After using `blk` update symbols, the assembler generates a block that automatically updates the address of the symbols used in the program, e.g.:

```
pf      smb 'PRINTF'
      jsr pf
```

The assembler inserts the correct symbol address after `jsr`.

This declaration is not transitive, i.e. the following example leads to an assembly error:

```
cm      smb 'COMTAB'
wp      equ cm-1.      (Error !)
      sta wp
```

Instead, you have to do the following:

```
cm      smb 'COMTAB'
      sta cm-1      (ok !)
```

All symbol declarations must first be defined in the program, i.e. before all other declarations and before the actual program.

**The following instructions are only necessary for compatibility with Quick Assembler:**

## **opt b**

Parameters for the assembly, only for the compatibility with Quick Assembler, whereby the bits of `b` have the following meaning:

Bits 0-1 output of source

- 00 – none
- 01 – only at error
- 10 – complete source

Bits 6-7 Objekttyp

- 11 – without header,
- 01, 10 – with Atari DOS header

Example for Atari DOS with output of the entire source code:  
opt %01000010

## org a

Defines a new block and creates a header as defined with **opt** and sets the program counter to **a**. This instruction is only necessary for compatibility with Quick Assembler, for blocks see pseudo instruction **blk**.

## lst all|bad|not

Option for the output of the source text during assembly:

- not – no output
- all – output of complete source
- bad – output of lines with error

## Blocks

The most important new feature in SpartaDOS X is the ability to write programs that can be easily moved. Since the 6502 processor has no relative addressing (with the exception of brief conditional jumps), the ICD programmers used special processes for loading program blocks. The entire process always loads a relocatable block from MEMLO. Then MEMLO is incremented by the length of the block and then a special block is loaded to update addresses. All addresses in the program block are zero-based. So it is enough to add the MEMLO value to get the correct address. Which addresses should be updated and which not? There is a special block for this which contains coded pointers to these addresses. After the Reloc block or blocks, a **blk update addresses** must be executed so that the program can be executed. It is also necessary after Sparta blocks, where instructions (or vectors) refer to Reloc or Empty blocks.

Another innovation is the introduction of symbols. Some SpartaDOS X service routines are defined by names. These names are always 8 letters long (as are file names). Instead of vector or jump arrays (as in the Atari operating system), symbols defined with the pseudo instruction **smb** are used. After reading a block or program blocks, SpartaDOS X loads the block to update the symbols and exchanges addresses in the program in a similar way to Reloc blocks. Symbols can be used in Reloc and Sparta blocks.

The programmer can define his own symbols to replace Sparta DOS X symbols, or entirely new symbols that can be used by other programs. This is done using the update new block. New symbols must be implemented in a Reloc block.

The number of relocatable blocks (Reloc and Empty blocks) is limited to 7 by SpartaDOS X.

Blocks can be combined to form chains, e.g.:

```
blk sparta $600
```

```
...  
  
blk reloc main  
...  
  
blk empty $100 main  
...  
  
blk reloc extended  
...  
  
blk empty $200 extended
```

This means that instructions in these blocks can apply to all blocks in the chain. This chain is not destroyed by address or symbol updates, but only by new symbol definitions or another type of block (e.g. DOS).

Such a chain only makes sense if all blocks are loaded in the same memory type (main or extended) or if the program changes the memory accordingly.

Instructions and vectors in Reloc and Empty blocks should not refer to Sparta blocks. This can lead to an error if the program is loaded with the SpartaDOS X instruction LOAD and is only used later. While Reloc and Empty blocks are safe, it is not certain what is in memory where the last Sparta block was.

It is just as dangerous to reference in Reloc and Empty blocks in Sparta blocks (reason as in section above). However, when installing overlays (.sys files) with INSTALL, this is sometimes required and therefore allowed. A Sparta block can also be initialized (via INITAD \$2E2).

Address collisions can occur between Sparta, Reloc and Empty blocks. Fast Assembler recognizes references to other blocks on the basis of the addresses, whereby addresses from \$1000 are assumed for Reloc and empty blocks. When shuffling these blocks, make sure that Sparta blocks are below \$1000 (e.g. \$600) or above the last movable block. Usually \$4000 is enough. This error is not recognized by the assembler.

# Error Messages

Undeclared label 224(\$E0)  
Undefined label or symbol or recursive labels.

Label declared twice 225(\$E1)  
Label or symbol defined twice.

Unexpected eol 226(\$E2)  
Unexpected line break means there should be at least one character or parameter in the line.

Too many passes 227(\$E3)  
Too many passes when the number of passes exceeds 8.

Too big number 228(\$E4)  
Number too large, the number exceeded the allowed 4 byte range.

String error 229(\$E5)  
Text expression error, no closing quotation mark or empty phrase.

Illegal symbol 230(\$E6)  
Illegal character in line.

Branch to far 231(\$E7)  
The relative jump is beyond the range of +127 and -128 bytes.

Improper type 232(\$E8)  
Addressing type not allowed for the given command.

Label missing 233(\$E9)  
Missing label, EQU and SMB pseudo commands must always be preceded by a label.

Expression expected 234(\$EA)  
Expected expression, after a numerical an expression must follow.

Too many blocks 235(\$EB)  
Too many blocks, the total number of blocks cannot exceed 256 and the number of RELOC and EMPTY blocks cannot exceed 7.

Undefined or too long 236(\$EC)  
Undefined or too long label, when defining labels a label block must be defined before using them, and the result of the address expression must not be larger than 2 bytes.

Improper block type 237(\$ED)  
Wrong type of block, e.g. UPDATE NEW block cannot follow DOS block.

Too long or invalid symbol 238(\$EE)  
The expression is too large or contains a symbol.

Parenthesis not balanced 239(\$EF)  
Missing parentheses.

Too many operations 240(\$F0)  
Too many operations in expression, the number of operations is limited to 32.



Unexpected symbol 241(\$E1)

Unexpected symbol, symbols cannot be used in blocks other than SPARTA or RELOC and in block definitions.

Internal error 242(\$E2)

Internal error, please drop me an email with instruction to reproduce ([holgerjanz@msn.com](mailto:holgerjanz@msn.com))