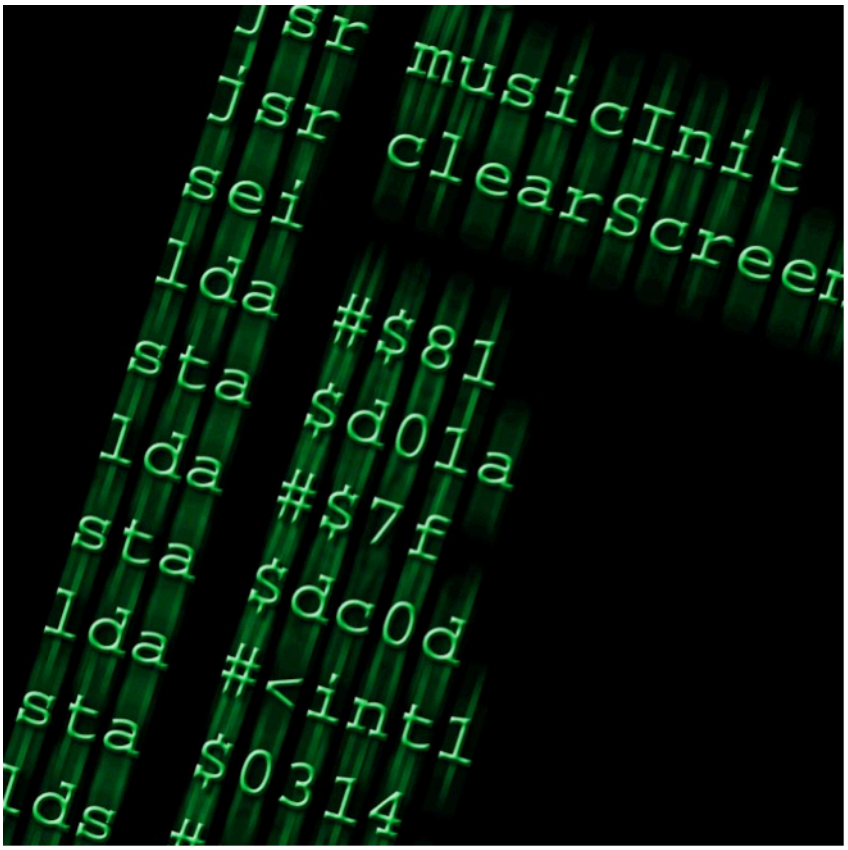
Kick Assembler

Reference Manual



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Chapter 1
Introduction

Welcome to Kick Assembler, an advanced MOS 65xx assembler combined with a Java Script like script language.

The assembler has all the features you would expect of a modern assembler like macros, illegal and DTV opcodes and commands for unrolling loops. It also has features like pseudo commands, import of SID files, import of standard graphic formats and support for 3rd party Java plugins. The script language makes it easy to generate data for your programs. This could be data such as sine waves, coordinates for a vector object, or graphic converters. Writing small data generating programs directly in you assembler source code is much handier than writing them in external languages like Java or C++.The script language and the assembler is integrated. Unlike other solutions, where scripts are prepassed, the script code and the assembler directives works together giving a more complete solution.

As seen by the size of this manual, Kick Assembler has a lot of functionality. You don't need to know it all to use the assembler, and getting to know all the features may take some time. If you are new to Kick Assembler, a good way to start is to read Chapter 2, *Getting Started*, Chapter 3, *Basic Assembler Functionality* and Chapter 4, *Introducing the Script Language* and then supplement with the features you need.

This is the third version of Kick Assembler. The first version (1.x) was a normal 6510 cross assembler developed around 2003 and was never made public. The second version (2.x) was developed in 2006 and combined the assembler with a script language, giving you the opportunity to write programs that generate data for the assembler code. Finally in august 2006 the project went public. The third version (3.x) improved the underlying assembling mechanism using a flexible pass algorithm, recording of side effects and handling of invalid values. This gave better performance, and made it possible make more advance feature. Through the years the project have grown quite big, with a professional setup including a its own code repository, a large automated test suite and automatic building and deploying.

A lot of people have contributed with valuable comments and suggestions by mail and on CSDB. Thanks guys. Your feedback is greatly appreciated. I would especially like to thank Martin ‘Cruzer’ Kristensen for proofreading and testing the assembler; Gunni ‘Dragnet’ Rode and Bastiaan ‘Mace’ for proofreading; Gerwin Klein for doing JFlex (the lexical analyser used for this assembler); Scott Hudson, Frank Flannery and C. Scott Ananian for doing CUP (The parser generator). And finally, Thanks to XMLMind for sponsoring the project with a pro version of their XML editor in which this manual is written.

I would like to hear from people that use Kick Assembler so do not hesitate to write your comments to kickassembler@no.spam.theweb.dk (<- Remove no.spam. for real address).

I wish you happy coding..

Chapter 2
Getting Started

This chapter is written to quickly get you started using Kick Assembler. The details of the assembler's functionalities will be presented later.

2.1. Running the Assembler

Kick Assembler run on any platform with Java5.0 or higher installed. Java can be downloaded for free on Javas website (http://java.com/en/download/index.jsp). To assemble the file myCode.asm simply go to a command prompt and write:

```
java –jar kickass.jar myCode.asm
```

And that's it.

Having problems with Java? Some Windows users found that Java couldn't be reached from the command prompt after installation. If this is the case you have to insert it in your path environment variable. You can test it by writing:

```
java –version
```

Java will now display the Java version if it's correctly installed.

2.2. An Example Interrupt

Below is a little sample program to quickly get you started using Kick Assembler. It sets up an interrupt, which play some music. It shows you how to use non-standard features such as the .pc directive, comments, how to use macros and include external files. This should be enough to get you (kick) started.

```
//--------------------------------------------------------
//--------------------------------------------------------
//   Simple IRQ
//--------------------------------------------------------
//--------------------------------------------------------
.pc = $4000 “Main Program”
        lda #$00
        sta $d020
        sta $d021
        lda #$00
        jsr $1000    // init music
        sei
        lda #<irq1
        sta $0314
        lda #>irq1
        sta $0315
        asl $d019
        lda #$7b
        sta $dc0d
        lda #$81
        sta $d01a
        lda #$1b
        sta $d011
        lda #$80
        sta $d012
        cli
this:   jmp this

//--------------------------------------------------------
```

```
irq1:
        asl $d019
        :SetBorderColor(2)
        jsr $1003    // play music
        :SetBorderColor(0)
        pla
        tay
        pla
        tax
        pla
        rti

//-------------------------------------------------------------
.pc=$1000 “Music”
.import binary “ode to 64.bin”

//-------------------------------------------------------------
// A little macro
.macro SetBorderColor(color) {
        lda #color
        sta $d020
}
```

2.3. Configuring the Assembler

Kick Assembler has a lot of command line options (a summary is given in Appendix A, *Quick Reference*). For example, if you assemble your program with the –showmem option you will get a memorymap shown after assembling:

```
java –jar kickass.jar –showmem myCode.asm
```

By placing a file called KickAss.cfg in the same folder as the KickAss.jar, you can set command line options that are used at every assembling. Lets say you always wants to have shown a memorymap after assembling and then have the result executed in the C64 emulator VICE. Then you write the following in the KickAss.cfg file:

```
-showmem
-execute “c:/c64/winvice/x64.exe –confirmexit”
```

(Replace c:/c64/winvice/ with a path that points to the vicefolder on your machine)

Chapter 3
Basic Assembler Functionality

This chapter describes the mnemonics and the basic directives that are not related to the script language.

3.1. Mnemonics

In Kick Assembler you can write assembler mnemonics the traditional way:

```
lda #0
sta $d020
sta $d021
```

However, it ignores format statements such as newline and tabs so you can format your program in any way you like. If you wish, you can write your entire program in one line:

```
lda #0 sta $d020 sta $d021
```

This comes in handy when using the script language. Kick Assembler supports all opcodes, also the illegal ones. A complete list of commands and their opcodes in the each mode is shown here:

Table 3.1. Mnemonics

cmd	noarg	imm	zp	zpx	zpy	izx	izy	abs	abx	aby	ind	rel
adc		$69	$65	$75		$61	$71	$6d	$7d	$79		
ahx							$93			$9f		
alr		$4b										
anc		$0b										
anc2		$2b										
and		$29	$25	$35		$21	$31	$2d	$3d	$39		
arr		$6b										
asl	$0a		$06	$16				$0e	$1e			
axs		$cb										
bcc												$90
bcs												$b0
beq												$f0
bit			$24					$2c				
bmi												$30
bne												$d0
bpl												$10
brk	$00											
bvc												$50
bvs												$70
clc	$18											
cld	$d8											
cli	$58											
clv	$b8											
cmp		$c9	$c5	$d5		$c1	$d1	$cd	$dd	$d9		

cmd	noarg	imm	zp	zpx	zpy	izx	izy	abs	abx	aby	ind	rel
cpx		$e0	$e4					$ec				
cpy		$c0	$c4					$cc				
dcp			$c7	$d7		$c3	$d3	$cf	$df	$db		
dec			$c6	$d6				$ce	$de			
dex	$ca											
dey	$88											
eor		$49	$45	$55		$41	$51	$4d	$5d	$59		
inc			$e6	$f6				$ee	$fe			
inx	$e8											
iny	$c8											
isc			$e7	$f7		$e3	$f3	$ef	$ff	$fb		
jmp								$4c			$6c	
jsr								$20				
las										$bb		
lax		$ab	$a7		$b7	$a3	$b3	$af		$bf		
lda		$a9	$a5	$b5		$a1	$b1	$ad	$bd	$b9		
ldx		$a2	$a6		$b6			$ae		$be		
ldy		$a0	$a4	$b4				$ac	$bc			
lsr	$4a		$46	$56				$4e	$5e			
nop	$ea											
ora		$09	$05	$15		$01	$11	$0d	$1d	$19		
pha	$48											
php	$08											
pla	$68											
plp	$28											
rla			$27	$37		$23	$33	$2f	$3f	$3b		
rol	$2a		$26	$36				$2e	$3e			
ror	$6a		$66	$76				$6e	$7e			
rra			$67	$77		$63	$73	$6f	$7f	$7b		
rti	$40											
rts	$60											
sax			$87		$97	$83		$8f				
sbc		$e9	$e5	$f5		$e1	$f1	$ed	$fd	$f9		
sbc2		$eb										
sec	$38											
sed	$f8											
sei	$78											
shx										$9e		
shy									$9c			
slo			$07	$17		$03	$13	$0f	$1f	$1b		
sre			$47	$57		$43	$53	$4f	$5f	$5b		

cmd	noarg	imm	zp	zpx	zpy	izx	izy	abs	abx	aby	ind	rel
sta			$85	$95		$81	$91	$8d	$9d	$99		
stx			$86		$96			$8e				
sty			$84	$94				$8c				
tas										$9b		
tax	$aa											
tay	$a8											
tsx	$ba											
txa	$8a											
txs	$9a											
tya	$98											
xaa		$8b										

DTV opcodes are also supported. To use these you have to use the –dtv option at the command line when running Kick Assembler. The DTV commands are:

Table 3.2. DTV Mnemonics

cmd	noarg	imm	zp	zpx	zpy	izx	izy	abs	Abx	aby	ind	rel
bra												$12
sac		$32										
sir		$42										

3.2. Argument Types

Kick Assembler uses the traditional notation for addressing modes / argument types:

Table 3.3. Argument Types

Mode	Example
No argument	nop
Immediate	lda #$30
Zeropage	lda $30
Zeropage,x	lda $30,x
Zeropage,y	ldx $30,y
Indirect zeropage,x	lda ($30,x)
Indirect zeropage,y	lda ($30),y
Abolute	lda $1000
Absolute,x	lda $1000,x
Absolute,y	lda $1000,y
Indirect	jmp ($1000)
Relative to program counter	bne loop

An argument is converted to its zeropage mode if possible. This means that lda $0030 will generate an lda command in its zeropage mode[1].

You can force the assembler to use a given addressing mode by using mnemonic extensions like this:

[1] If the argument is unknown (eg. an unresolved label) in the first pass, the assembler will assume it's a 16 bit value

```
lda.a $0030  // Uses absolute mode
sta.z label  // Uses zeropage mode
ldx.im $10   // Equal to lda #$10
label:
```

Here is a list of the extensions:

Table 3.4. Mnemonic Extensions

Ext	Mode	Example
im, imm	Immediate	
z, zp	Zeropage	ldx.z $1234
zx, zpx	Zeropage,x	lda.zpx table
zy, zpy	Zeropage,y	
izx, izpx	Indirect zeropage,x	
izy, izpy	Indirect zeropage,y	
a, abs	Abolute	ldx.a $0010
ax, absx	Absolute,x	lda.absx $1234
ay, absy	Absolute,y	
I, ind	Indirect	jmp.i $1000
r, rel	Relative to program counter	

3.3. Number formats

Kick Assembler supports the standard number formats:

Table 3.5. Number formats

Prefix	Format	Example
	Decimal	lda #42
$	Hexadecimal	lda #$2a, lda #$ff
%	Binary	lda #%101010

3.4. Labels and Multi Labels

Label declarations in Kick Assembler end with ':' and have no postfix when referred to, as shown in the following program:

```
loop:   inc $d020
        inc $d021
        jmp loop
```

Kick Assembler also supports multi labels, which are labels that can be declared more than once. These are useful to prevent name conflicts between labels. A multi label starts with a '!' and when your reference it you have to end with a '+' to refer to the next multi label or '-' to refer to the previous multi label:

```
        ldx #100
!loop:  inc $d020
        dex
        bne !loop- // Jumps to the previous instance of !loop

        ldx #100
!loop:  inc $d021
        dex
        bne !loop- // Jumps to the previous instance of !loop
```

or

```
        ldx #10
!loop:
        jmp !+ // Jumps over the two next nops to the ! label
        nop
        nop
!:      jmp !+ // Jumps over the two next nops to the ! label
        nop
        nop
!:
        dex
        bne !loop- // Jumps to the previous !loop label
```

Another way to avoid conflicting variables is to use user defined scopes, which are explained in the scoping section of Chapter 4, *Introducing the Script Language*.

A '*' returns the value of the current memory location so instead of using labels you can write your jumps like this:

```
// Jumps with '*'
        jmp *

        inc $d020
        inc $d021
        jmp *-6

// The same jumps with labels
this:   jmp this

!loop:  inc $d020
        inc $d021
        jmp !loop-
```

3.5. Memory Directives

The .pc directive is used to set the program counter. A program should always start with a .pc directive to tell the assembler where to put the program. Here are some examples of use:

```
.pc = $1000 "Program"
        ldx #10
!loop:  dex
        bne !loop-
        rts

.pc = $4000 "Data"
        .byte 1,0,2,0,3,0,4,0

.pc = $5000 "More data"
        .text "Hello"
```

The last argument is optional and is used to name the memory block created by the directive. When using the '-showmem' option when running the assembler a memory map will be generated that displays the memory usage and block names. The map of the above program looks like this:

```
Memory Map
----------
$1000-$1005 Program
$4000-$4007 Data
$5000-$5004 More data
```

By using the virtual option on the .pc directive you can declare a memory block that is not saved in the resulting file.

```
.pc = $0400 "Data Tables 1" virtual
table1: .fill $100,0
table2: .fill $100,0

.pc = $0400 "Data Tables 2" virtual
table3: .fill $150,0
table4: .fill $100,0

.pc = $1000 "Program"
        ldx #0
        lda table1,x
        …
```

Note that virtual memory blocks can overlap other memory blocks. They are marked with an asterisk in the memory map.

```
Memory Map
----------
*$0400-$05ff Data Tables 1
*$0400-$064f Data Tables 2
$1000-$1005 Program
```

Since virtual memory blocks aren't saved, the above example will only save the memory from $1000 to $1005.

With the .align directive, you can align the program counter to a given interval. This is useful for optimizing your code as crossing a memory page boundary yields a penalty of one cycle for memory referring commands. To avoid this, use the .align command to align your tables:

```
.pc = $1000 "Program"
        ldx #1
        lda data,x
        rts

.pc = $10ff   //Bad place for the data
.align $100   //Alignment to the nearest page boundary saves a cycle
data:   .byte 1,2,3,4,5,6,7,8
```

In case you want your code placed at position $1000 in the memory but want it assembled like it was placed at $2000, you can use the .pseudopc directive:

```
.pc = $1000 "Program to be relocated at $2000"
.pseudopc $2000 {
loop:   inc $d020
        jmp loop  // Will produce jmp $2000 instead of jmp $1000
}
```

3.6. Data Directives

The .byte, .word, .dword and .text directives are used to generate byte, word (one word= two bytes), dword (double word = 4 bytes) and text data as in standard 6510 assemblers.

```
.byte 1,2,3,4      // Generates the bytes 1,2,3,4
.word $2000,$1234  // Generates the bytes $00,$20,$34,$12
.dword $12341234   // Generates the bytes $34,$12,$34,$12
```

With the .fill directive you can fill a section of the memory with bytes. It works like a loop and automatically sets the variable i to the byte number.

```
.fill 5, 0 // Generates byte 0,0,0,0,0
.fill 5, i // Generates byte 0,1,2,3,4
.fill 256, 127.5 + 127.5*sin(toRadians(i*360/256)) // Generates a sine curve
```

3.7. Import Directives

With the .import directive you can import external files into your source. You can import source, binary, C64, and text files:

```
// Import and assemble the sourcefile ‘standardlibrary.asm’
.import source "StandardLibrary.asm"

// import the bytes from the file 'music.bin'
.import binary "Music.bin"

// Import the bytes from the c64 file 'charset.c64'
// (Same as binary but skips the first two address bytes)
.import c64 "charset.c64"

// Import the chars from the text file
// (Converts the bytes as a .text directive would do)
.import text "scroll.txt"
```

When Kick Assembler searches for a file, it first look in the current directory. Afterwards it looks in the directories supplied by the ‘-libdir’ parameter when running the assembler. This enables you to create standard libraries for files you use in several different sources. A command line could look like this:

```
java –jar kickass.jar myProgram.asm –libdir ..\music –libdir c:\code\stdlib
```

If you build source code libraries you might want to ensure that the library is only included once in your code. This can be done by placing a .importonce directive in the top of the library file:

```
File1.asm:
.importonce
.print "This will only be printed once!"

File2.asm:
.import source "File1.asm" // This will import File1
.import source "File1.asm" // This will not import anything
```

3.8. Comments

Comments are pieces of the program that are ignored by the assembler. Kick Assembler supports line and block comments known from languages such as C++ and Java. When the assembler sees ‘//’ it ignores the rest of that line. C block comments ignores everything between /* and */.

```
/*------------------------------------------------------------
This little program is made to demonstrate comments
------------------------------------------------------------*/
        lda #10
        sta $d020  // This is also a comment
        sta /* Comments can be placed anywhere */ $d021
        rts
```

Traditional 65xx assembler line comments (;) are not supported since the semicolon is used in for-loops in the script language.

3.9. Console Output

With the .print directive you can output text to the user while assembling. For example:

```
.print "Hello world"
.var x=2
.print "x="+x
```

This will give the following output from the assembler:

```
parsing
flex pass 1
Output pass
  Hello world
  x=2.0
```

Notice that the output is given during the output pass. You can also print the output immediately with the .printnow command. This is useful for debugging script where errors prevent the execution of the output pass. The .printnow command will print the output in each pass, and in some passes the output might be incomplete due to lack of information. In the following example we print a label that isn't resolved in the first pass:

```
.printnow "loop=$" + toHexString(loop)

.pc = $1000
loop: jmp loop
```

This will give the following output:

```
parsing
flex pass 1
   loop=$<<Invalid String>>
flex pass 2
   loop=$1000
Output pass
```

If you detect an error while assembling, you can use the .error directive to terminate the assembling and display an error message:

```
.var width = 45
.if (width>40) .error "width can’t be higher than 40"
```

Chapter 4
Introducing the Script Language

In this chapter the basics of the script language is introduced. We will focus on how Kick Assembler evaluates expressions, the standard values and libraries. Later chapters will deal with more advanced areas.

4.1. Expressions

Kick assembler has a built in mechanism for evaluating expressions. An example of an expression is 25+2*3/x. Expressions can be used in many different contexts, for example to calculate the value of a variable or to define a byte:

```
lda #25+2*3/x
.byte 25+2*3/x
```

Standard assemblers can only calculate expressions based on numbers, while Kick Assembler can evaluate expressions based on many different types like: Numbers, Booleans, Strings, Lists, Vectors, and Matrixes. So, if you want to calculate an argument based on the second value in a list you write:

```
lda #35+myList.get(1) // 1 because first element is number 0
```

Or perhaps you want to generate your argument based on the x-coordinate of a vector:

```
lda #35+myVector.getX()
```

Or perhaps on the basis of the x-coordinate on the third vector in a list:

```
lda #35+myVectorList.get(2).getX()
```

I think you get the idea by now. Kick Assembler's evaluation mechanism is much like those in modern programming languages. It has a kind of object oriented approach, so calling a function on a value(/object) executes a function specially connected to the value. Operators like +, -,*, /, ==, !=, etc., are seen as functions and are also specially defined for each type of value.

In the following chapters, a detailed description of how to use the value types and functions in Kick Assembler will be presented.

4.2. Variables, Constants and User Defined Labels

With variables you can store data for later use. Before you can use a variable you have to declare it. You do this with the .var directive:

```
.var x=25
lda #x    // Gives lda #25
```

If you want to change x later on you write:

```
.eval x=x+10
lda #x    // Gives lda #35
```

This will increase x by 10. The .eval directive is used to make Kick Assembler evaluate expressions. In fact, the .var directive above is just a convenient shorthand of '.eval var x =25', where 'var' is subexpression that declares a variable (this will come in handy later when we want to define variables in for-loops).

Two other shorthands exist: the ++ and the -- operator, which automatically calls a referenced variable with +1 or -1. For example:

```
        .var x = 0
        .eval x++    // Gives x=x+1
        .eval x--    // Gives x=x-1
```

Experienced users of modern programming languages will know that assignments return a value, e.g. x = y = z = 25 first assigns 25 to z, which returns 25 that is assigned to y, which returns 25 that is assigned to x. Kick Assembler supports this as well. Notice that the ++ and -- works as real ++ and –- postfix operators, which means that they return the original value and not the new (Ex: .eval x=0 .eval y=x++, will set x to 1 and y to 0)

You can also declare constants:

```
.const c=1              // Declares the constant c to be 1
.eval const pi=3.1415   // Declares the constant pi using the eval form
.const name = "Camelot" // Constants can assume any value, for example string
```

A constant can't be assigned a new value, so .eval pi=22 will generate an error. Note that not all values are immutable. If you define a constant that points to a list, the content of the list can still change. If you want to make a mutable value immutable, you can use its lock() function, which will lock it's content:

```
.const immutableList = List().add(1,2,3).lock()
```

After this you will get an error if you try to add an element or modify existing elements.

With the .enum statement you can define enumerations, which are series of constants:

```
.enum {singleColor, multiColor}      // Defines singleColor=0, multiColor=1
.enum {effect1=1,effect2=2,end=$ff}  // Assigns values explicitly
.enum {up,down,left,right, none=$ff} // You can mix implicit and explicit
                                     // assignment of values
```

Variables and constants can only be seen after they are declared while labels can be seen in the entire scope. You can define a label with the .label directive like you define variables and constants:

```
        // This fails
        inc myLabel1
        .const myLabel1 = $d020

        // This is ok
        inc myLabel2
        .label myLabel2 = $d020
```

4.3. Scoping

You can limit the scope of you variables and labels by defining a user defined scope. This is done by {..}. Everything between the brackets is defined in a local scope and can't be seen from the outside.

```
Function1: {
        .var length = 10
        ldx #0
        lda #0
loop:   sta table1,x
        inx
        cpx #length
        bne loop
}

Function2: {
        .var length = 20 // doesn’t collide with the previous ‘length’
        ldx #0
        lda #0
loop:   sta table2,x     // the label doesn’t collide with the previous ‘loop’
```

```
        inx
        cpx #length
        bne loop
}
```

Scopes can be nested as many times as you wish as demonstrated by the following program:

```
.var x = 10
{
    .var x=20
    {
        .print "X in 2nd level scope read from 3rd level scope is " + x
        .var x=30
        .print "X in 3rd level scope is " + x
    }
    .print "X in 2nd level scope is " + x
}
.print "X in first level scope is " + x
```

The output of this is:

```
X in 2nd level scope read from 3rd level scope is 20.0
X in 3rd level scope is 30.0
X in 2nd level scope is 20.0
X in first level scope is 10.0
```

4.4. Numeric Values

Numeric values are numbers, covering both integers and floats. Standard numerical operators (+,-,*, and /) work as in standard programming languages. You can combine them with each other and they will obey the standard precedence rules. Here are some examples:

```
25+3
5+2.5*3-10/2
charmem + y * $100
```

In practical use they can look like this:

```
.var charmem = $0400
        ldx #0
        lda #0
loop:   sta charmem + 0*$100,x
        sta charmem + 1*$100,x
        sta charmem + 2*$100,x
        sta charmem + 3*$100,x
        inx
        bne loop
```

You can also use bitwise operators to perform and, or, exclusive or, and bit shifting operations.

```
        .var x=$12345678
        .word x & $00ff, [x>>16] & $00ff // gives .word $0078, $0034
```

Special for 65xx assemblers are the high and low-byte operators (>,<) that are typically used like this:

```
        lda #<interrupt1   // Takes the lowbyte of the interupt1 value
        sta $0314
        lda #>interrupt1   // Takes the high byte of the interupt1 value
        sta $0315
```

Table 4.1. Numeric Values

Name	Operator	Examples	Description
Unary minus	-		Inverts the sign of a number.
Plus	+	10+2 = 12	Adds two numbers.
Minus	-	10-8=2	Subtracts two numbers.
Multiply	*	2*3 =6	Multiply two numbers.
Divide	/	10/2 = 5	Divides two numbers.
High byte	>	>$1020 = $10	Returns the second byte of a number.
Low byte	<	<$1020 = $20	Returns the first byte of a number.
Bitshift left	<<	2<<2 = 8	Shifts the bits by a given number of spaces to the left.
Bitshift right	>>	2>>1=1	Shifts the bits by a given number of spaces to the right.
Bitwise and	&	$3f & $0f = $f	Performs bitwise and between two numbers.
Bitwise or	|	$0f | $30 = $3f	Performs a bitwise or between two numbers.
Bitwise eor	^	$ff ^ $f0 = $0f	Performs a bitwise exclusive or between two numbers.

You can get the number representation of an arbitrary value by using the general .number() function. Eg.

```
.print ‘x’.number()
```

4.5. Parentheses

Since traditional 65xx assembler notation has already used soft parenthesis to signal an indirect addressing mode, you will have to use hard parenthesis to specify a sub expression that must be evaluated before others.

```
lda #2+5*2    // gives lda #12
lda #[2+5]*2  // gives lda #14
```

You can nest as many parentheses as you want, so [[[[2+4]]]*3]+25.5 is a legal expression.

4.6. String Values

Strings are used to contain text. You can define a string like this:

```
.var message = "Hello World"
.text message    // Gives .text "Hello world"
```

Normally quotes (") will denote the end or start of the string. You can use the quote as a character in the string by adding a backslash in front of the quote:

```
.text “He said: \"Hello World\""
```

Every object has a string representation and you can concatenate strings with the + operator. For example:

```
.var x=25
.var myString= “X is “ + x    // Gives myString = "X is 25"
```

You can use the .print directive to print a string to the console while assembling. This is useful when debugging. Printing x and y can be done like this:

```
        .print "x="+x
        .print "y="+y
```

You can also print labels to see which location they refer to. If you do this, it's best to convert the label value to hexadecimal notation first:

```
        .print “int1=$”+toHexString(int1)

int1:   sta regA+1
        stx regX+1
        sty regY+1
        lsr $d019
        // Etc.
```

Here is a list of functions/operators defined on strings:

Table 4.2. String Values

Function/Operator	Description
+	Appends two strings.
size()	Returns the number of characters in the string.
charAt(n)	Returns the character at position n.
substring(i1,i2)	Returns the substring beginning at i1 and ending at i2 (char at i2 not included).
asNumber()	Converts the string to a number value (eg, “35”.asNumber()).
asBoolean()	Converts the string to a boolean value (eg, “true”.asBoolean()).

Here are the functions that take a number value and convert it to a string:

Table 4.3. Numbers to Strings

Function	Description
toIntString(x)	Return x as a integer string (eg x=16.0 will return “16”).
toBinaryString(x)	Return x as a binary string (eg x=16.0 will return “10000”).
toOctalString(x)	Return x as a octal string (eg x=16.0 will return “20”).
toHexString(x)	Return x as a hexadecimal string (eg x=16.0 will return “10”).

You can get the string representation of an arbitrary value by using the general .string() function. Eg.

```
        .print 1234.string().charAt(2)    // Prints 3
```

4.7. Char Values

Char values, or characters, are used like this:

```
        lda #'H'
        sta $0400
        lda #'i'
        sta $0401

        lda #"?!#".charAt(1)
        sta $0402

        .byte 'H','e','l','l','o',' '
        .text "World"+'!'
```

In the above example, chars are used in two ways. In the first examples their numeric representation are used as arguments to the lda commands and in the final example, '!'s string representation is appended to the "World" string.

Char values is a subclass of number values, which means that it has all the functions that are placed on the number values, so you can do stuff like.

```
        lda #'H'+1 // Same as lda #'I'
        sta $0400
        lda #'A'+1 // Same as lda #'B'
        sta $0401
        lda #'L'+1 // Same as lda #'M'
        sta $0402
```

4.8. The Math Library

Kick Assembler's math library is built upon the Java 5.0 math library. This means that nearly every constant and command in Java's math library is available in Kick Assembler. Here is a list of available constants and commands. For further explanation consult the Java 5.0 documentation at Suns homepage. The only non Java math library function is mod (modulo).

Table 4.4. Math Constants

Constant	Value
PI	3.141592653589793
E	2.718281828459045

Table 4.5. Math Functions

Function	Description
abs(x)	Returns the absolute (positive) value of x.
acos(x)	Returns the arc cosine of x.
asin(x)	Returns the arc sine of x.
atan(x)	Returns the arc tangent x
atan2(y,x)	Returns the angle of the coordinate (x,y) relative to the positive x-axis. Useful when converting to polar coordinates.
cbrt(x)	Returns the cube root of x.
ceil(x)	Rounds up to the nearest integer.
cos(r)	Returns the cosine of r.
cosh(x)	Returns the hyperbolic cosine of r.
exp(x)	Returns ex.
expm1(x)	Returns ex-1.

Function	Description
floor(x)	Rounds down to the nearest integer.
hypot(a,b)	Returns sqrt(x2+y2).
IEEEremainder(x,y)	Returns the remainder of the two numbers as described in the IEEE 754 standard.
log(x)	Returns the natural logarithm of x.
log10(x)	Returns the base 10 logarithm of x.
log1p(x)	Returns log(x+1).
max(x,y)	Returns the highest number of x and y.
min(x,y)	Returns the smallest number of x and y.
mod(a,b)	Converts a and b to integers and returns the remainder of a/b.
pow(x,y)	Returns x raised to the power of y.
random()	Returns a random number x where $0 \leq x < 1$.
round(x)	Rounds x to the nearest integer.
signum(x)	Returns 1 if x>0, -1 if x<0 and 0 if x=0.
sin(r)	Returns the sine of r.
sinh(x)	Returns the hyperbolic sine of x.
sqrt(x)	Returns the square root of x.
tan(r)	Returns the tangent of r.
tanh(x)	Returns the hyperbolic tangent of x.
toDegrees(r)	Converts a radian angle to degrees.
toRadians(d)	Converts a degree angle to radians.

Here are some examples of use.

```
// Load a with a random number
lda #random()*256

// Generate a sine curve
.fill 256,round(127.5+127.5*sin(toRadians(i*360/256)))
```

Chapter 5
Branching and Looping

Kick Assembler has control directives that let you put conditions on when a directive is executed and how many time it is executed. These are explained in this chapter.

5.1. Boolean Values

The conditions for control directives are given by Boolean values, which are values that can be true or false. They are generated and used as in programming languages like Java and C#. The following are examples of boolean variables:

```
.var myBoolean1 = true    // Set the variable to true
.var myBoolean2 = false   // Set the variable to false
.var fourHigherThanFive = 4>5 // Sets fourHigherThanFive = false
.var aEqualsB = a==b    // Sets true if a is the same as b
.var xNot10 = x!=10     // Sets true if x doesn’t equal 10
```

Here is the standard set of operators for generating Booleans:

Table 5.1. Boolean generating Functions

Name	Operator	Example	Description
Equal	==	a==b	Returns true if a equals b, otherwise false.
Not Equal	!=	a!=b	Returns true if a doesn't equal b, otherwise false.
Greater	>	a>b	Returns true if a is greater than b, otherwise false.
Less	<	a<b	Returns true if a is less than b, otherwise false.
Greater than	>=	a>=b	Returns true if a is greater than or equal to b, otherwise false.
Less than	<=	a<=b	Returns true if a is less or equal to b, otherwise false.

All the operators are defined for numeric values, other values have defined a subset of the above. E.g. you can't say that one boolean is greater than another, but you can see if they have the same values:

```
.var b1 = true==true    // Sets b1 to true
.var b2 = true!=[10<20] // Sets b2 to false
```

Boolean values have a set of operators assigned. These are the following:

Table 5.2. Boolean Operators

Name	Operator	Example	Description
Not	!	!a	Returns true if a is false, otherwise false.
And	&&	a&&b	Returns true if a and b are true, otherwise false.

Name	Operator	Example	Description
Or	||	A||b	Returns true if a or b are true, otherwise false.

And are used like this:

```
.var allTrue = 10HigherThan100 && aEqualsB // Is true if the two boolean
                                           // arguments are true.
```

Like in languages like C++ or Java, the && and || operators are short circuited. This means that if the first argument of an && operator is false, then the second argument won't be evaluated since the result can only be false. The same happens if the first argument of an || operator is true.

5.2. The .if directive

If-directives work like in standard programming languages. With an .if directive you have the proceeding directive executed only if a given boolean expression is evaluated to true. Here are some examples:

```
// Set x to 10 if x is higher that 10
.if (x>10) .eval x=10

// Only show rastertime if the 'showRasterTime' boolean is true
.var showRasterTime = false
.if (showRasterTime) inc $d020
jsr PlayMusic
.if (showRasterTime) dec $d020
```

You can group several statements together in a block with {…} and have them executed together if the boolean expression is true:

```
// If IrqNr is 3 then play the music
.if (irqNr==3) {
    inc $d020
    jsr music+3
    dec $d020
}
```

By adding an else statement you can have an expression executed if the boolean expression is false:

```
// Add the x'th entry of a table if x is positive or
// subtract it if x is negative
.if (x>=0) adc zpXtable+x else sbc zpXtable+abs(x)


// Init an offset table or display a warning if the table length is exceeded
.if (i<tableLength) {
   lda #0
   sta offset1+i
   sta offset2+i
} else {
   .error "Error!! I is too high!"
}
```

5.3. Question mark if's

As known from languages like Java and C++ you can use the write compact if expression in the following form:

```
    condition ? trueExpr : falseExpr
```

Some examples of use:

```
.var x= true ? "hello" : "goodbye"   // Sets x = "hello"
.var y= [20<10] ? 1 : 2              // Sets y=2

.var max = a>b ? a:b

.var debug=true
inc debug ? $d020:$d013  // Increases $d020 since debug=true

.var boolean = max(x,minLimit==null?0:minLimit) // Takes care of null limit
```

5.4. The .for directive

With the .for directive you can generate loops as in modern programming languages. The .for directive takes an init expression list, a boolean expression, and an iteration list separated by a semicolon. The last two arguments and the body are executed as long as the boolean expression evaluates to true.

```
// Prints the numbers from 0 to 9
.for(var i=0;i<10;i++)  .print "Number " + i

// Make data for a sine wave
.for(var i=0;i<256;i++) .byte round(127.5+127.5*sin(toRadians(360*i/256)))
```

Since argument 1 and 3 are lists, you can leave them out, or you can write several expressions separated by comma:

```
// Print the numbers from 0 to 9
.var i=0
.for (;i<10;) {
    .print i
   .eval i++
}

// Sum the numbers from 0 to 9 and print the sum at each step
.for(var i=0, var sum=0;i<10;sum=sum+i,i++)
    .print “The sum at step “ + I “ is “ + sum
```

With the for loop you can quickly generate tables and unroll loops. You can, for example, do a classic ‘blitter fill’ routine like this:

```
.var blitterBuffer=$3000
.var charset=$3800
.for (x=0;x<16;x++) {
    for(var y=0;y<128;y++) {
        if (var y=0)  lda blitterBuffer+x*128+y
        else          eor blitterBuffer+x*128+y
        sta charset+x*128+y
    }
}
```

5.5. Optimization Considerations when using Loops

Here is a tip if you want to optimize your assembling. Kick assembler has two modes of executing directives. ‘Function Mode’ is used when the directive is placed inside a function or define directive, otherwise ‘Asm Mode’ is used. ‘Function Mode’ is executed fast but is restricted to script commands only (.var, .const, .for, etc.), while ‘Asm Mode’ remembers intermediate results so the assembler won't have to make the same calculations in succeeding passes.

If you make heavy calculations and get slow performance or lack of memory, then place your for loops inside a define directive or inside a function. No time or memory will be wasted to record intermediate results, and the define directive or the directive that called the function, will remember the result in the succeeding passes.

Read more about the define directive in the section ‘Working with mutable values’.

Chapter 6
Data Structures

In the chapter, we will examine user defined data and predefined structures.

6.1. User Defined Structures

It's possible to define your own structures. A structure is a collection of variables like for example a point that consist of an x and a y coordinate:

```
// Define a point structure
.struct Point {x,y}

// Create a point with x=1 and y=2 and print it
.var p1 = Point(1,2)
.print ”p1.x=” + p1.x
.print ”p1.y=” + p1.y

// Create a point with the default contructor and modify its arguments
.var p2 = Point()
.eval p2.x =3
.eval p2.y =4
```

You define a structure with the .struct directive. The above structure has the name ‘Point’ and consists of the variables x and y. To create an instance of the structure, you use its name as a function. You can either supply no arguments or give the init values of all the variables. You use the values generated by structures as any other variables, ex:

```
        lda #0
        ldy #p1.y
        sta charset+[p1.x>>3]*height,y
```

You can get access to informations about the struct and access the fields in a more generic way by using the struct’s functions:

```
.struct Person{firstName,lastName}
.var p1 = Person(“Peter”,”Schmeichel”)

.print p1.getStructName()        // Prints ‘Person’
.print p1.getNoOfFields()        // Prints ‘2’
.print p1.getFieldNames().get(0) // Prints ‘firstName’

.eval p1.set(0,”Casper”)         // Sets firstName to Casper
.print p1.get(“lastName”)        // Prints “Schmeichel”


// Copy values from one struct to another
.var p2 = Person()
.for (var i=0; i<p1.getNoOfFields(); i++)
    .eval p2.set(i,p1.get(i))

// Print the content of a struct:
//   firstName = Casper
//   lastName = Schmeichel
.for (var i=0; i<p1.getNoOfFields(); i++) {
    .print p1.getFieldNames().get(i) + “ = “ + p1.get(i)
}
```

Here is a list of the functions defined on struct values:

Table 6.1. Struct Value Functions

Functions	Description
getStructName()	Returns the name of the structure.
getNoOfFields()	Returns the number of defined fields.
getFieldNames()	Returns a list containing the field names.
get(index)	Returns the field value of the field given by an integer index (0 is the first defined filed).
get(name)	Returns the value of the field given by a field name string.
set(index,value)	Sets the value of a field given by an integer index..
set(name,value)	Sets the value of a field given by a name.

6.2. List Values

List values are used to hold a list of other values. To create a list you use the 'List()' function. It takes one argument that tells how many elements it contains. If it is left out, the created list will be empty. Use the get and set operations to retrieve and set elements.

```
        .var myList = List(2)
        .eval myList.set(0,25)
        .eval myList.set(1, "Hello world")
        .byte myList.get(0)    // Will give .byte 25
        .text myList.get(1)    // Will give .text "Hello world"
```

You can determine the number of elements in a list with the size function and the add function adds additional elements.

```
        .var greetingsList = List()
        .eval greetingsList.add("Fairlight", "Oxyron", "etc." )
        .byte listSize = greetingsList.size()    // gives .byte 3
```

A compact way to fill a list with elements is:

```
        .var greetingsList = List().add("Fairlight", "Oxyron", "etc.")
```

Here is a list of functions defined on list values:

Table 6.2. List Values

Functions	Description
get(n)	Gets the n'th element (first element starts at zero).
set(n,value)	Sets the n'th element (first element starts at zero).
add(value1, value2, …)	Add elements to the end of the list.
size()	Returns the size of the list.
remove(n)	Removes the n'th element.
shuffle()	Puts the elements of the list in random order.
reverse()	Puts the elements of the list in reverse order.
sort()	Sorts the elements of the list (only numeric values are supported).

6.3. Working with Mutable Values

The list value described in the previous chapter is special since it is mutable, which means it can change its contents. At one point in time a list can contain the values [1,6,7] and at another time [1,4,8,9]. The values previously described in the manual (Numbers, Strings, Booleans) are immutable since instances like 1, false, or “Hello World” can’t change. In Kick Assembler 3, you will have to lock mutable values if you want to use them in a pass different from the one in which they were defined. When a value is locked, it becomes immutable and calling a function that modifies its content will cause an error. There are two ways to lock a mutable value. You can call its lock function:

```
// Locking a list with the lock function
.var list1 = List().add(1,3,5).lock()
```

Or you can define it inside a .define directive:

```
// The define directive locks the defined variables outside its scope
.define list2, list3 {
    .var list2 = List().add(1,2)

    .var list3= List()
    .eval list3.add("a")
    .eval list3.add("b")
}
//.eval list3.add("c") // This will give an error
```

The .define directive defines the symbols that are listed after the .define keyword (list2 and list3). The directives inside {…} are executed in a new scope so any local defined variables can't be seen from the outside. After executing the inner directives, the defined values are locked and inserted as constants in the outside scope.

The inner directives are executed in 'function mode', which is a bit faster and requires less memory than ordinary execution. So if you are using for loops to do some heavy calculations, you can optimize performance by placing your loop inside a define directive. As the name 'function mode' suggests, directives placed inside functions are also executed in ‘function mode’. In ‘function mode’ you can only use script directives (like .var, .const, .eval, .enum, etc) while byte output generating directives (like lda #10, byte $22, .word $33, .fill 10, 0) are not allowed.

6.4. Hashtable Values

Hashtables are tables that map keys to values. You can define a hashtable with the Hashtable() function. To enter and retrieve values you use the put and get functions, and with the keys function you can retrieve a list of all keys in the table:

```
.define ht {
    // Define the table
    .var ht = Hashtable()

    // Enter some values (put(key,value))
    .eval ht.put("ram", 64)
    .eval ht.put("bits", 8)
    .eval ht.put(1, "Hello")
    .eval ht.put(2, "World")
    .eval ht.put("directions", List().add("Up","Down","Left","Right"))
}

// Retrieve the values
.print ht.get(1)    // Prints Hello
.print ht.get(2)    // Prints World
.print "ram = " + ht.get("ram") + "kb"    // Prints ram=64kb

// Print all the keys
.var keys = ht.keys()
.for (var i=0; i<keys.size(); i++) {
    .print keys.get(i)    // Prints "ram", "bits", 1, 2, directions
```

```
}
```

When a value is used as a key then it is the values string representation that is used. This means that ht.get(“1.0”) and ht.get(1) returns the same element. If you try to get an element that isn't present in the table, null is returned.

Table 6.3. Hashtable Values

Function	Description
put(key,value)	Maps 'key' to 'value'. If the key is previously mapped to a value, the previous mapping is lost.
get(key)	Returns the value mapped to 'key'. A null value is returned if no value has been mapped to the key.
keys()	Returns a list value of all the keys in the table.
containsKey(key)	Returns true if the key is defined in the table, otherwise false.
remove(key)	Removes the key and its value from the table.

Chapter 7
Functions and Macros

This chapter shows how to group directives together in units for later execution. In other words, how to define and use functions, macros and finally pseudo commands which are a special kind of macros.

7.1. Functions

You can define you own functions which you can use like any of the build in library functions. Here is an example of a function:

```
.function area(width,height) {
    .return width*height
}
.var x = area(3,2)
lda #10+area(4,8)
```

Functions consist of non-byte generating directives like .eval, .for, .var, and .if. When the assembler evaluates the .return directive it returns the value given by the proceeding expression. If no expression is given, or if no .return directive is reached, a null value is returned. Here are some more examples of functions:

```
// Returns a string telling if a number is odd or even
.function oddEven(number) {
    .if ([number&1] == 0 ) .return “even”
    else .return “odd”
}

// Inserts null in all elements of a list
.function clearList(list) {
    // Return if the list is null
    .if (list==null) .return

    .for(var i=0; i<list.size(); i++) {
        list.set(i,null)
    }
}

// Empty function – always returns null
.function emptyFunction() {
}
```

7.2. Macros

Macros are collections of assembler directives. When called, they generate code as if the directives where placed at the macro call. The following code defines and executes the macro ‘SetColor’:

```
// Define macro
.macro SetColor(color) {
    lda #color
    sta $d020
}

// Execute macro
:SetColor(1)
```

A macro can have any number of arguments. Macro calls are encapsulated in a scope, hence any variable defined inside a macro can't be seen from the outside. This means that a series of macro calls to the same macro doesn't interfere:

```
// Execute macro
:ClearScreen($0400,$20)   // Since they are encapsulated in a scope
:ClearScreen($4400,$20)   // the two resulting loop labels don't
                          // interfere


// Define macro
.macro ClearScreen(screen,clearByte) {
    lda #clearByte
    ldx #0
Loop:         // The loop label can't be seen from the outside
    sta screen,x
    sta screen+$100,x
    sta screen+$200,x
    sta screen+$300,x
    inx
    bne Loop
}
```

Notice that it is ok to use the macro before it is declared.

Macros in Kick Assembler are a little more flexible than ordinary macros. They can call other macros or even call themselves - Just make sure there is a condition to stop the recursion so you won't get an endless loop.

7.3. Pseudo Commands

Pseudo commands are a special kind of macros that takes command arguments, like #20, table,y or ($30),y as arguments just like mnemonics do. With these you can make your own extended commands. Here is an example of a mov command that moves a byte from one place to another:

```
.pseudocommand mov src;tar {
    lda src
    sta tar
}
```

You use the mov command like this:

```
:mov #10 ; $1000          // Sets $1000 to 10  (lda #10, sta $1000)
:mov source ; target      // target = source   (lda source, sta target)
:mov source,x ; target,y  // (lda source,x , sta target,y)
:mov #20 ; ($30),y        // (lda #20, sta ($30),y )
```

The arguments to a pseudo command are separated by semicolon and you can use any argument you would give to a mnemonic.

The command arguments are passed to the pseudo command as CmdValues. These are values that contain an argument type and a number value. You access these by their getter functions. Here is a table of the functions:

Table 7.1. CmdValue Functions

Function	Description	Example
getType()	Returns a type constant (See the table below for possibilities).	#20 will return AT_IMMEDIATE.
getValue()	Returns the value.	#20 will return 20.

The argument type constants are the following:

Table 7.2. Argument Type Constants

Constant	Example
AT_ABSOLUTE	$1000

Constant	Example
AT_ABSOLUTEX	$1000,x
AT_ABSOLUTEY	$1000,y
AT_IMMEDIATE	#10
AT_INDIRECT	($1000)
AT_IZEROPAGEX	($10,x)
AT_IZEROPAGEY	($10),y
AT_NONE	

Some addressing modes, like absolute zeropage and relative, are missing from the above table. This is because the assembler automatically detect when these should be used from the corresponding absolute mode.

You can construct new command arguments with the CmdArgument function. If you want to construct a new immediate argument with the value 100, you do it like this:

```
.var myArgument = CmdArgument(AT_IMMEDIATE, 100)
lda myArgument   // Gives lda #100
```

Now let's use the above functionalities to define a 16 bit instruction set. We start by defining a function that given the first argument will return the next in a 16 bit instruction.

```
.function 16bitnextArgument(arg) {
    .if (arg.getType()==AT_IMMEDIATE)
        .return CmdArgument(arg.getType(),>arg.getValue())
    .return CmdArgument(arg.getType(),arg.getValue()+1)
}
```

We always return an argument of the same type as the original. If it's an immediate argument we set the value to be the high byte of the original value, otherwise we just increment it by 1. This will supply the correct argument for the ABSOLUTE, ABSOLUTEX, ABSOLUTEY and IMMEDIATE addressing modes. With this we can easily define some 16 bits commands:

```
.pseudocommand inc16 arg {
    inc arg
    bne over
    inc 16bitnextArgument(arg)
over:
}

.pseudocommand mov16 src;tar {
    lda src
    sta tar
    lda 16bitnextArgument(src)
    sta 16bitnextArgument(tar)
}

.pseudocommand add16 arg1 ; arg2 ; tar {
    .if (tar.getType()==AT_NONE) .eval tar=arg1
    lda arg1
    adc arg2
    clc
    lda 16bitnextArgument(arg1)
    adc 16bitnextArgument(arg2)
    sta 16bitnextArgument(tar)
}
```

You can use these like this:

```
:inc16 counter
:mov16 #irq1; $0314
:mov16 #startAddress; $30
:add16 $30; #128
:add16 $30; #$1000; $32
```

Note how the target argument of the add16 command can be left out. When this is the case an argument with type AT_NONE is passed to the pseudo command and the first argument is then used as target.

With the pseudo command directive you can define your own extended instruction libraries, which speed up some of the more trivial tasks of programming.

Chapter 8
Namespaces

Namespaces are named scopes. When you enclose code in a scope, you hide information about the code for the outside. This is useful, since labels names won't collide, but sometimes you want to access these anyway. By using namespaces you can access this information. In this chapter the different uses of namespaces are explained.

8.1. The Namespace Directive

Suppose you want to divide your code into different parts with local labels and variables and want to access to some of the labels from the outside. This can be done with the .namespace directive:

```
        jsr part1.init
        jsr part1.exec
        jsr part2.init
        jsr part2.exec
        rts


.namespace part1 {
init:
        ...
        rts

exec:
        ...
        rts
}

.namespace part2 {
init:
        ...
        rts

exec:
        ...
        rts
}
```

Inside a namespace you reference the labels as usual, but from the outside you append the namespace name as prefix to the label as seen in the jsr commands. Namespaces can be nested which is seen in the following example:

```
        jsr part1.section1.exec
        rts


.namespace part1 {

        .namespace section1 {
        exec:
                ...
                rts
        }

        // You don’t have to append part1 here since we are already in
        // the part1 namespace
        jsr section2.exec

        .namespace section2 {
        exec:
```

```
                ...
                rts
        }
}
```

User defined labels can be accessed like normal labels, so if you want a constant to be exposed outside of your namespace then define it as a label:

```
.namespace vic {
    .label borderColor = $d020
    .label backgroundColor0 = $d021
    .label backgroundColor1 = $d022
    .label backgroundColor2 = $d023
}

        lda #0
        sta vic.backgroundColor0
        sta vic.borderColor
```

8.2. File Namespaces

If you want the entire sourcefile to be place in a namespace, you can put a .filenamespace directive in the top of the file.

```
.filenamespace mySpace
        .pc=$1000
start:  inc $d020
        jmp start
```

It's equivalent to using the .namespace directive but it will save a pair of brackets.

8.3. Label Namespaces

If you declare a scope after a label, the scope will automatically declare a namespace (Autonamespacing). This is handy if you use scoping to make the labels of your functions local. In the example below the clearScreen label and the succeeding scope creates a namespace with the name clearScreen.

```
        lda #' '
        sta clearScreen.fillbyte+1
        jsr clearScreen
        rts

clearScreen: {
fillbyte: lda #0
        ldx #0
loop:
        sta $0400,x
        sta $0500,x
        sta $0600,x
        sta $0700,x
        inx
        bne loop
        rts
}
```

The above code fills the screen with black spaces. The code that calls the clearScreen subroutine uses the namespace to access the fillbyte label. If you use the label directive to define the fillbyte label, the code can be done a little nicer:

```
        lda #'a'
        sta clearScreen2.fillbyte
```

```
        jsr clearScreen2
        rts

ClearScreen2: {
        .label fillbyte = *+1
        lda #0
        ldx #0
loop:
        sta $0400,x
        sta $0500,x
        sta $0600,x
        sta $0700,x
        inx
        bne loop
        rts
}
```

Now you don't have to remember to add one to the address before storing the fill byte. Autonamespacing works with both normal labels and the label directive, so its also possible to write programs like this:

```
.label mylabel1= $1000 {
    .label mylabel2 = $1234
}
.print “mylable2=”+mylabel1.mylabel2
```

8.4. Accessing Local Labels of Macros and Pseudocommands

Autonamespacing makes it possible to access local labels of executed Macros and pseudocommands as demonstrated in the following program:

```
.pc=$1000

start:
        inc c1.color
        dec c2.color
c1:     :setColor()
c2:     :setColor()
        jmp start

.macro setColor() {
        .label color = *+1
        lda #0
        sta $d020
}
```

Chapter 9
Import and Export

In this chapter we will look at other ways to get data in and out of Kick Assembler.

9.1. Passing Command Line Arguments to the Script

From the command line you can assign string values to variables, which can be read from the script. This is done with the ':' notation like this:

```
java –jar KickAss.jar mySource.asm :x=27 :sound=true :title=”Beta 2”
```

The three variables x, sound and beta2 and their string values will now be placed in a hashtable that can be accessed by the global variable cmdLineVars:

```
.print “version =” + cmdLineVars.get(“version”)
.var x= cmdLineVars.get(“x”).asNumber()
.var y= 2*x
.var sound = cmdLineVars.get(”sound”).asBoolean()
.if (sound) jsr $1000
```

9.2. Import of Binary Files

It's possible to load any file into a variable. This is done with the LoadBinary function. To extract bytes of the file from the variable you use the get function. You can also get the size of the file with the getSize function. Here is an example:

```
// Load the file into the variable ’data’
.var data = LoadBinary("myDataFile")

// Dump the data to the memory
myData: .fill data.getSize(), data.get(i)
```

When you know the format of the file, you can supply a template string that describes the memory blocks. Each block is given a name and a start address relative to the start of the file. When you supply a template to the LoadBinary function, the returned value will contain a get and a size function for each memory block:

```
.var dataTemplate = "Xcoord=0,Ycoord=$100, BounceData=$200"
.var file = LoadBinary(“moveData”, dataTemplate)
Xcoord:     .fill file.getXCoordSize(), file.getXCoord(i)
Ycoord:     .fill file.getYCoordSize(), file.getYCoord(i)
BounceData: .fill file.getBounceDataSize(), file.getBounceData(i)
```

There is a special template tag named 'C64FILE' that is used to load native c64 files. When this is in the template string, the LoadBinary function will ignore the two first byte of the file, since the first two bytes of a C64 file are used to tell the loader the start address of the file. Here is an example of how to load and display a Koala Paint picture file:

```
.const KOALA_TEMPLATE = "C64FILE, Bitmap=$0000, ScreenRam=$1f40, ColorRam=$2328,
 BackgroundColor = $2710"
.var picture = LoadBinary("picture.prg", KOALA_TEMPLATE)

        .pc = $0801 "Basic Program"
        :BasicUpstart($0810)

        .pc =$0810 "Program"
        lda #$38
```

```
        sta $d018
        lda #$d8
        sta $d016
        lda #$3b
        sta $d011
        lda #0
        sta $d020
        lda #picture.getBackgroundColor()
        sta $d021
        ldx #0
!loop:
        .for (var i=0; i<4; i++) {
           lda colorRam+i*$100,x
           sta $d800+i*$100,x
        }
        inx
        bne !loop-
        jmp *

.pc = $0c00             .fill picture.getScreenRamSize(), picture.getScreenRam(i)
.pc = $1c00 colorRam:   .fill picture.getColorRamSize(), picture.getColorRam(i)
.pc = $2000             .fill picture.getBitmapSize(), picture.getBitmap(i)
```

Notice how easy it is to reallocate the screen and color ram by combining the .pc and .fill directives. To avoid typing in format types too often, Kick Assembler has some build in constants you can use:

Table 9.1. BinaryFile Constants

Binary format constant	Blocks	Description
BF_C64FILE		A C64 file (The two first bytes are skipped)
BF_BITMAP_SINGLECOLOR	ColorRam,ScreenRam,Bitmap	The Bitmap single color format outputted from Timanthes.
BF_KOALA	Bitmap,ScreenRam,ColorRam,BackgroundColor	Files from Koala Paint
BF_FLI	ColorRam,ScreenRam,Bitmap	Files from Blackmails FLI editor.

So if you want to load a FLI picture, just write

```
.var fliPicture = LoadBinary("GreatPicture", BF_FLI)
```

The formats were chosen so they cover the outputs of Timanthes (NB. Timanthes doesn't save the background color in koala format, so if you use that you will get an overflow error).

TIP: If you want to know how data is placed in the above formats, just print the constant to the console while assembling. Example:

```
.print "Koala format="+BF_KOALA
```

9.3. Import of SID Files

The script language knows the format of SID files. This means that you can import files directly from the HVSC (High Voltage Sid Collection) which uses this format. To do this you use the LoadSid function which returns a value that represents the sidfile.

```
.var music = LoadSid("C:/c64/HVSC_44-all-of-them/C64Music/Tel_Jeroen/
Closing_In.sid")
```

From this you can extract data such as the init address, the play address, info about the music and the song data.

Table 9.2. SIDFileValue Properties

Attribute/Function	Description
header	The sid file type (PSID or RSID)
version	The header version
location	The location of the song
init	The address of the init routine
play	The address of the play routine
songs	The number of songs
startSong	The default song
name	A string containing the name of the module
author	A string containing the name of the author
copyright	A string containing copyright information
speed	The speed flags (Consult the Sid format for details)
flags	flags (Consult the Sid format for details)
startpage	Startpage (Consult the Sid format for details)
pagelength	Pagelength (Consult the Sid format for details)
size	The data size in bytes
getData(n)	Returns the n'th byte of the module. Use this function together with the size variable to store the modules binary data into the memory.

Here is an example of use:

```
//--------------------------------------------------------
//--------------------------------------------------------
//                    SID Player
//--------------------------------------------------------
//--------------------------------------------------------
.var music = LoadSid("Nightshift.sid")
:BasicUpstart2(start)
start:
        lda #$00
        sta $d020
        sta $d021
        ldx #0
        ldy #0
        lda #music.startSong-1
        jsr music.init
        sei
        lda #<irq1
        sta $0314
        lda #>irq1
        sta $0315
        asl $d019
        lda #$7b
        sta $dc0d
        lda #$81
        sta $d01a
        lda #$1b
        sta $d011
        lda #$80
        sta $d012
```

```
        cli
this:   jmp this
//-------------------------------------------------------
irq1:
        asl $d019
        inc $d020
        jsr music.play
        dec $d020
        pla
        tay
        pla
        tax
        pla
        rti
//-------------------------------------------------------
.pc=music.location "Music"
.fill music.size, music.getData(i)

//-------------------------------------------------------
// Print the music info while assembling
.print ""
.print "SID Data"
.print "--------"
.print "location=$"+toHexString(music.location)
.print "init=$"+toHexString(music.init)
.print "play=$"+toHexString(music.play)
.print "songs="+music.songs
.print "startSong="+music.startSong
.print "size=$"+toHexString(music.size)
.print "name="+music.name
.print "author="+music.author
.print "copyright="+music.copyright

.print ""
.print "Additional tech data"
.print "--------------------"
.print "header="+music.header
.print "header version="+music.version
.print "flags="+toBinaryString(music.flags)
.print "speed="+toBinaryString(music.speed)
.print "startpage="+music.startpage
.print "pagelength="+music.pagelength
```

Assembling the above code will create a musicplayer for the given sidfile and print the information in the music file while assembling:

```
  SID Data
  --------
  location=$1000
  init=$1d70
  play=$1003
  songs=1.0
  startSong=1.0
  size=$d78
  name=Nightshift
  author=Ari Yliaho (Agemixer)
  copyright=2001 Scallop

  Additional tech data
  --------------------
  header=PSID
  header version=2.0
  flags=100100
  speed=0
```

```
  startpage=0.0
```

TIP: If you use the –libdir option to point to your HVSC main directory, you don’t have to write long filenames. For example:

```
.var music = LoadSid("C:/c64/HVSC_44-all-of-them/C64Music/Tel_Jeroen/
Closing_In.sid")
```

will be

```
.var music = LoadSid("Tel_Jeroen/Closing_In.sid")
```

9.4. Converting Graphics

Kick Assembler makes it easy to convert graphics from gif and jpg files to the basic C64 formats. A picture can be loaded into a picture value by the LoadPicture function. The picture value can then be accessed by various functions depending on which format you want. The following will place a single color logo in a standard 32x8 char matrix charset placed at $2000.

```
.pc = $2000
.var logo = LoadPicture("CML_32x8.gif")
.fill $800, logo.getSinglecolorByte([i>>3]&$1f, [i&7] | [i>>8]<<3)
```

If you don't like the compact form of the .fill command you can use a for loop instead. The following will produce the same data:

```
.pc = $2000
.var logo = LoadPicture("CML_32x8.gif")
.for (var y=0; y<8; y++)
    .for (var x=0;x<32; x++)
        .for(var charPosY=0; charPosY<8; charPosY++)
            .byte logo.getSinglecolorByte(x,charPosY+y*8)
```

The LoadPicture can take a color table as the second argument. This is used to decide which bit pattern is produced by a pixel. In single color mode there are two bit patters (%0 and %1) and multi color mode has four (%00, %01, %10 and %11). If you don’t specify a color table, a default table is created based on the colors in the picture. However, normally you wish to control which color is mapped to a bit pattern. The following shows how to convert a picture to a 16x16 multi color char matrix charset:

```
.pc = $2800 “Logo”
.var picture = LoadPicture("Picture_16x16.gif",
                           List().add($444444, $6c6c6c,$959595,$000000))
.fill $800, picture.getMulticolorByte(i>>7,i&$7f)
```

The four colors added to the list are the RGB values for the colors that are mapped to each bit pattern.

Finally the picture value contains a getPixel function from which you can get the RGB color of a pixel. This comes in handy when you want to make your own format for some special purpose.

Attributes and functions available on picture values:

Table 9.3. PictureValue Functions

Attribute/Function	Description
width	Returns the width of the picture in pixels.
height	Returns the height of the picture in pixels.
getPixel(x,y)	Returns the RGB value of the pixel at position x,y. Both x and y are given in pixels.

Attribute/Function	Description
getSinglecolorByte(x,y)	Converts 8 pixels to a single color byte using the color table. X is given as a byte number (= pixel position/8) and y is given in pixels.
getMulticolorByte(x,y)	Converts 4 pixels to a multi color byte using the color table. X is given as a byte number (= pixel position/8) and y is given in pixels. (NB. This function ignores every second pixel since the C64 multi color format is half the resolution of the single color.)

9.5. Writing to User Defined Files

With the createFile function you can create/overwrite a file on the disk. You call it with a file name and it returns a value that can be used to write data to the file:

```
.var myFile = createFile("breakpoints.txt")
.eval myFile.writeln("Hello World")
```

IMPORTANT! For security reasons, you will have to use the –afo switch on the command line otherwise file generation will be blocked. Eg “java –jar KickAss.jar source.asm -afo” will do the trick.

File creation is useful for generating extra data for emulators. The following example shows how to generate a file with breakpoint for VICE:

```
.var brkFile = createFile("breakpoints.txt")

.macro break() {
    .eval brkFile.writeln(“break “ + toHexString(*))
}

.pc=$0801 “Basic”
:BasicUpstart (start)

.pc=$1000 "Code"
start:
    inc $d020
    :break()
    jmp start
```

When running VICE with the breakpoint file (use the –moncommands switch), VICE will run until the break and then exit to the monitor.

Here is a list of the functions on a file value:

Table 9.4. FileValue Functions

Attribute/Function	Description
Attribute/Function	Description.
writeln(text)	Writes the ‘text’ to the file and insert a line shift.
writeln()	Insert a line shift.

9.6. Exporting Labels to other Sourcefiles

By using the –symbolfile option at the commandline it’s possible export all the assembled symbols. The line

```
java –jar KickAss.jar source1.asm –symbolfile
```

will generate the file source1.sym while assembling. Lets say the content of source1 is:

```
.filenamespace source1
.pc =$2000
clearColor:
        lda #0
        sta $d020
        sta $d021
        rts
```

The content of source1.sym will be:

```
.namespace source1 {
        .label clearColor = $2000
}
```

It's now possible to refer to the labels of source1.asm from another file just by importing the .sym file:

```
.import source “source1.sym”
jsr source1.clearColor
```

9.7. Exporting Labels to VICE

By using the –vicesymbols option you can export the labels to a .vs file that can be read by the VICE emulator. For example:

```
java –jar KickAss.jar source1.asm –vicesymbols
```

Chapter 10
Modifiers

With modifiers, you can modify assembled bytes before they are stored to the target file. It could be you want to encrypt, pack or crunch the bytes. Currently, the only way to create a modifier is to implement a java plugin (See the plugin chapter).

10.1. Modify Directives

You can modify the assembled bytes of a limited block or of the whole source file. To modify the whole source file use the .filemodify directive at the top of the file. The following modifies the whole file with the modifier 'MyModifier' called with the parameter 25.

```
.filemodify MyModifier(25)
```

To modify a limited block you use the .modify directive:

```
.modify MyModifier() {
    .pc =$8080
main:
    inc $d020
    dec $d021
    jmp main

    .pc =$1000
    .fill $100, i
}
```

Chapter 11
Special Features

Misc features

11.1. Basic Upstart Program

To make the assembled machine code run on a C64 or in an emulator, it's useful to include a little basic program that starts your code (for example: 10 sys 4096). The BasicUpstart macro is standard macro that helps you to create programs like that. The following program shows how it's used:

```
.pc = $0801 "Basic Upstart"
:BasicUpstart(start)    // 10 sys$0810

.pc =$0810 "Program"
start:
        inc $d020
        inc $d021
        jmp start
```

TIP: Insert at basic upstart program in the start of your programs and use the –execute option to start Vice. This will automatically load and execute your program in Vice after successful assembling.

There is a second variation of the basic upstart macro that also takes care of setting up memory blocks:

```
:BasicUpstart2(start)    // 10 sys$0810
start:
        inc $d020
        inc $d021
        jmp start
```

If you want to see the script code for the macros, you can look in the autoinclude.asm file in the KickAss.jar file.

11.2. Opcode Constants

When making self modifying code or code that unrolls speed code, you have to know the value of the opcodes involved. To make this easier, all the opcodes have been given their own constant. The constant is found by writing the mnemonic in uppercase and appending the addressing mode. For example, the constant for a rts command is RTS and 'lda #0' is LDA_IMM. So, to place an rts command at target you write:

```
        lda #RTS
        sta target
```

You get the size of a mnemonic by using the asmCommandSize command

```
.var rtsSize = asmCommandSize(RTS)      //rtsSize=1
.var ldaSize1 = asmCommandSize(LDA_IMM) //ldaSize1=2
.var ldaSize2 = asmCommandSize(LDA_ABS) //ldaSize2=3
```

Here are a list of the addressing modes and constant examples:

Table 11.1. Addressing Modes

Argument	Description	Example constant	Example command
	None	RTS	rts
IMM	Immediate	LDA_IMM	lda #$30
ZP	Zeropage	LDA_ZP	lda $30

Argument	Description	Example constant	Example command
ZPX	Zeropage,x	LDA_ZPX	lda $30,x
ZPY	Zeropage,y	LDX_ZPY	ldx $30,y
IZPX	Indirect zeropage,x	LDA_IZPX	lda ($30,x)
IZPY	Indirect zeropage,y	LDA_IZPY	lda ($30),y
ABS	Absolute	LDA_ABS	lda $1000
ABSX	Absolute,x	LDA_ABSX	lda $1000,x
ABSY	Absolute,y	LDA_ABSY	lda $1000,y
IND	Indirect	JMP_IND	jmp ($1000)
REL	Relative	BNE_REL	bne loop

11.3. Colour Constants

Kick Assembler has build in the C64 colour constants:

Table 11.2. Colour Constants

Constant	Value
BLACK	0
WHITE	1
RED	2
CYAN	3
PURPLE	4
GREEN	5
BLUE	6
YELLOW	7
ORANGE	8
BROWN	9
LIGHT_RED	10
DARK_GRAY/DARK_GREY	11
GRAY/GREY	12
LIGHT_GREEN	13
LIGHT_BLUE	14
LIGHT_GRAY/LIGHT_GREY	15

Example of use:

```
        lda #BLACK
        sta $d020
        lda #WHITE
        sta $d021
```

11.4. Making 3D Calculations

To make it easy to to make 3D Calculations, Kick Assembler supports vector and matrix values.

Vector values are used to hold 3D vectors. They are created by the Vector function that takes x, y and z as argument:

```
.var v1 = Vector(1,2,3)
.var v2 = Vector(0,0,2)
```

You can access the coordinates of the vector by its get functions and do the most common vector operations by the assigned functions. Here are some examples:

```
.var v1PlusV2 = v1+v2
.print "V1 scaled by 10 is " +  [v1*10]
.var dotProduct = v1*v2
```

Here is a list of vector functions and operators:

Table 11.3. Vector Value Functions

Function/Operator	Example	Description
get(n)		Returns the n'th coordinate (x=0, y=1, z=2).
getX()		Returns the x coordinate.
getY()		Returns the y coordinate.
getZ()		Returns the z coordinate.
+	Vector(1,2,3)+Vector(2,3,4)	Returns the sum of two vectors.
-	Vector(1,2,3)-Vector(2,3,4)	Returns the result of a subtraction between the two vectors.
* Number	Vector(1,2,3)* 4.2	Return the vector scaled by a number.
* Vector	Vector(1,2,3)*Vector(2,3,4)	Returns the dot product.
/	Vector(1,2,3)/2	Divides each coordinate by a factor and returns the result.
X(v)	Vector(0,1,0).X(Vector(1,0,0))	Returns the cross product between two vectors.

The matrix value represents a 4x4 matrix. You create it by using the Matrix function, or one of the other constructor functions described later. You access the entries of the matrix by using its get and set functions:

```
.var matrix = Matrix()    // Creates an identity matrix
.eval matrix.set(2,3,100)
.print "Matrix.get(2,3)=" + matrix.get(2,3)
.print "The entire matrix=" + matrix
```

In 3d graphics matrixes are usually used to describe a transformation of a vector space. That can be to move the coordinates, to scale them, to rotate then, etc. The Matrix() operator creates an identity matrix, which is one that leaves the coordinates unchanged. By using the set function you can construct any matrix you like. However, Kick Assembler has constructor functions that create the most common transformation matrixes:

Table 11.4. Matrix Value Constructors

Function	Description
Matrix()	Creates an identity matrix.
RotationMatrix(aX,aY,aZ)	Creates a rotation matrix where aX, aY and aZ are the angles rotated around the x, y and z axis. The angles are given in radians.
ScaleMatrix(sX,sY,sZ)	Creates a scale matrix where the x coordinate is scaled by sX, the y-coordinate by sY and the z-coordinate by sZ.

Function	Description
MoveMatrix(mX,mY,mZ)	Creates a move matrix that moves mX along the x-axis, mY along the y-axis and mZ along the z-axis.
PerspectiveMatrix(zProj)	Creates a perspective projection where the eye-point is placed in (0,0,0) and coordinates are projected on the XY-plane where z=zProj.

You can multiply the matrixes and thereby combine their transformations. The transformation is read from right to left, so if you want to move the space 10 along the x axis and then rotate it 45 degrees around the z-axis, you write:

```
.var m = RotationMatrix(0,0,toRadians(45))*MoveMatrix(10,0,0)
```

To transform a coordinate you multiply the matrix to transformed vector:

```
.var v = m*Vector(10,0,0)
.print "Transformed v=" + v
```

The functions defined on matrixes are the following:

Table 11.5. Matrix Value Functions

Function/Operator	Example	Description
get(n,m)		Gets the value at n,m.
set(n,m,value)		Sets the value at n,m.
*Vector	Matrix()*Vector(1,2,3)	Return the product of the matrix and a vector.
*Matrix	Matrix()*Matrix()	Returns the product of two matrixes.

Here is a little program to illustrate how matrixes can be used. It pre calculates an animation of a cube that rotates around the x, y and z-axis and is projected on the plane where z=2.5. The data is placed at the label ‘cubeCoords’:

```
//-------------------------------------------------------------------------------
// Objects
//-------------------------------------------------------------------------------
.var Cube = List().add(
          Vector(1,1,1),  Vector(1,1,-1),  Vector(1,-1,1),  Vector(1,-1,-1),
          Vector(-1,1,1), Vector(-1,1,-1), Vector(-1,-1,1), Vector(-1,-1,-1))


//-------------------------------------------------------------------------------
// Macro for doing the precalculation
//-------------------------------------------------------------------------------
.macro PrecalcObject(object, animLength, nrOfXrot, nrOfYrot, nrOfZrot) {

    // Rotate the coordinate and place the coordinates of each frams in a list
    .var frames = List()
    .for(var frameNr=0; frameNr<animLength;frameNr++) {
        // Set up the transform matrix
        .var aX = toRadians(frameNr*360*nrOfXrot/animLength)
        .var aY = toRadians(frameNr*360*nrOfYrot/animLength)
        .var aZ = toRadians(frameNr*360*nrOfZrot/animLength)
        .var zp = 2.5 // z-coordinate for the projection plane
        .var m = ScaleMatrix(120,120,0)*
                    PerspectiveMatrix(zp)*
                    MoveMatrix(0,0,zp+5)*
                    RotationMatrix(aX,aY,aZ)
```

```
        // Transform the coordinates
        .var coords = List()
        .for (var i=0; i<object.size(); i++) {
            .eval coords.add(m*object.get(i))
        }
        .eval frames.add(coords)
    }

    // Dump the list to the memory
    .for (var coordNr=0; coordNr<object.size(); coordNr++) {
        .for (var xy=0;xy<2; xy++) {
            .fill animLength, $80+round(frames.get(i).get(coordNr).get(xy))
        }
    }
}
//-----------------------------------------------------------------------------
// The vector data
//-----------------------------------------------------------------------------
.align $100
cubeCoords: :PrecalcObject(Cube,256,2,-1,1)
//-----------------------------------------------------------------------------
```

Chapter 12
Testing

Kick Assembler has .assert directives that are useful for testing. They were made to make it easy to test the assembler itself, but you can use them for testing your own pseudo-commands, macros, functions. When assertions are used, the assembler will automatically count the number of assertions and the number of failed assertions and display these when the assembling has finished.

12.1. Asserting expressions

With the assert directive you can test the value of expressions. It takes three arguments: a description, an expression, and an expected result.

```
.assert "2+5*10/2", 2+5*10/2, 27
.assert "2+2", 2+2, 5
.assert "Vector(1,2,3)+Vector(1,1,1)", Vector(1,2,3)+Vector(1,1,1), Vector(2,3,4)
```

When assembling this code the assembler prints the description, the result of the expression and the expected result. If these don't match an error message is appended:

```
2+5*10/2=27.0 (27.0)
2+2=4.0 (5.0) – ERROR IN ASSERTION!!!
Vector(1,2,3)+Vector(1,1,1)=(2.0,3.0,4.0) ((2.0,3.0,4.0))
```

12.2. Asserting errors in expressions

To make sure that an expression gives an error when the user gives the wrong parameters to a function, use the .asserterror directive:

```
.asserterror "Test1" , 20/10
.asserterror "Test2" , 20/false
```

In the above example test1 will fail since its perfectly legal to divide 20 by 10. Test2 will produce the expected error so this assertion is ok. The above will give the following output:

```
Test1 – ERROR IN ASSERTION!
  Test2 – OK. | Can't get a numeric representation from a value of type boolean
```

12.3. Asserting code

The assert directive has a second form which makes it possible to compare pieces of assembled code:

```
.assert "Test2", { lda $1000 }, {ldx $1000}

.assert "Test", {
    .for (var i=0; i<4; i++)
        sta $0400+i
}, {
    sta $0400
    sta $0401
    sta $0402
    sta $0403
}
```

The assert directive will give an ok or failed message and the assembled result as output. The output of the above example is as follows:

```
  Test1 – FAILED! | 2000:ad,00,10  -- 2000:ae,00,10
  Test2 – OK. | 2000:8d,00,04,8d,01,04,8d,02,04,8d,03,04
```

12.4. Asserting errors in code

Like the assert directive the asserterror directive also has a form that can assert code:

```
.asserterror “Test” , { lda #”This must fail”}
```

Output:

```
Test – OK. | The value of a Command Argument Value must be an integer. Can’t get an
 integer from a value of type ‘string’
```

Chapter 13
3rd Party Java plugins

It's possible to write you own plugins for Kick Assembler. Currently the following types of plugins are supported:

- *Macro Plugins* - Implements macros
- *Modify Plugins* – Implements modifiers
- *Archive Plugins* – Used to group the above plugins in one unit

13.1. The Test Project

Before going any further I suggest you download the plugin development test eclipse project from the Kick Assembler website.

To use it do the following:

1. Create an Eclipse workspace.
2. 'Import->Existing Projects into workspace->Select archive file' and select the downloaded project file.
3. Replace the KickAss.jar file in the jars folder with the newest version, if necessary.

You are now ready to start. In the src folder you can see examples of how the plugins are made. The files in PluginTest shows how to use them and in the launch folder is launch files for running the examples (Rightclick->Run As).

13.2. Registering your Plugins

To work with plugins you should do two things. When assembling you should make your compiled java class visible from the java classpath. If you are using eclipse to run your Kick Assembler, like in the example project, you don't have to worry about this. If you are using the command line you will have to set either the classpath environment variable or use the classpath option of the java command.

Secondly you should tell Kick Assembler about your plugin. There are two ways to do this. If your plugin is only used in one of your projects, you should use the .plugin directive. Eg:

```
.plugin "test.plugins.macros.MyMacro"
```

If the plugin should be available every time you use Kick Assembler, you place the class name in a line in the file 'KickAss.plugin' which should be placed in the same locations as the KickAss.jar. Using // in the start of the line makes it a comment. Example of a KickAss.plugin file:

```
// My macro plugins
test.plugins.macros.MyMacro1
test.plugins.macros.MyMacro2
test.plugins.macros.MyMacro3
```

13.3. Macro Plugins

Macro plugins a java classes that implements the IMacro interface:

```
public interface IMacro {
   String getName();
   byte[] execute(IValue[] parameters, IEngine engine);
}
```

A simple example of a macro is:

```
import cml.kickass.plugins.interf.*;

public class MyMacro implements IMacro{
   @Override
   public String getName() {
      return "MyMacro";
   }

   @Override
   public byte[] execute(IValue[] parameters, IEngine engine) {
      engine.print(“Hello world from MyMacro!”);
      return new byte[0];
   }
}
```

You execute it as a normal macro:

```
.plugin "test.plugins.macros.MyMacro"
:MyMacro()
```

And get the expected output ‘Hello World from MyMacro!’. The ‘arguments’ parameter is the parameters parsed to the macro. The result is returned as a byte array and the ‘engine’ parameter is used to do additional communication with the Kick Assembler engine. The interfaces of the two parameters are described in the following sections.

13.4. The IValue Interface

Objects that implements the interface IValue represents values like numbers, strings and booleans. The IValue interface contains the following methods to extract information from the value:

Table 13.1. IValue Interface

Method	Description
int getInt();	Gets an integer from the value if possible, otherwise it will give an error message.
Double getDouble();	Gets a double from the value if possible, otherwise it will give an error message.
String getString();	Gets a string from the value if possible, otherwise it will give an error message.
Boolean getBoolean();	Gets a Boolean from the value if possible, otherwise it will give an error message.
List<IValue> getList();	Gets at list of values if possible, otherwise it will give an error message. The list implements size(), get(i), isEmpty() and iterator().
Boolean hasIntRepresentation();	Tells if you can get an integer from the value. Every number value can produce an integer. 3.2 will produce 3).
boolean hasDoubleRepresentation();	Tells if you can get a double from the value.
boolean hasStringRepresentation();	Tells if you can get a string from the value.
boolean hasBooleanRepresentation();	Tells if you can get a boolean from the value.
boolean hasListRepresentation();	Tells if you can get a list from the value.

13.5. The IEngine Inteface

The IEngine interface is used to do additional communication to Kick Assembler. It has the following methods:

Table 13.2. IEngine Interface

Method	Description
File getFile(String filename);	Opens a file with the given filename. The assembler will look for the file as it would look for a soucecode file. If it isn't present in the current directory, it will look in the library directories. It will return null if the file can't be found.
File getCurrentDirectory();	Gets the current directory.
void print(String message);	Prints a message to the screen. Works like the .print directive.
void printNow(String message);	Prints a message to the screen. Works like the .printnow directive.
void error(String message);	Prints an error message and stops execution. Works like the .error directive. Important! This method will throw an AsmException which you have to pass through any try-catch block used in your code.

13.6. Modifyer Plugins

You can implement modifiers the same way as macros (See the modifier chapter for an explanation for these). The interface looks like this:

```
public interface IModifier {
   public String getName();
   byte[] execute(List<IMemoryBlock> memoryBlocks, IValue[] parameters, IEngine
 engine);
}
```

The only difference from the macro interface is the list of memory blocks. These are the blocks defined inside the modify directive. The memory block objects contain the following functions:

Table 13.3. IMemoryBlock Interface

Method	Description
int getStartAddress()	The start address of the memory block.
byte[] getBytes()	The assembled bytes of the memory block.

13.7. Plugin Archives

You can collect more plugins in one archive. The makes it possible to register them with only one plugin directive. To create an archive you implement a class of the IArchive interface:

```
public interface IArchive {
   public List<Object> getPluginObjects();
}
```

An implementation could look like this:

```
public class MyArchive implements IArchive{
   @Override
   public List<Object> getPluginObjects() {
      List<Object> list = new ArrayList<Object>();
      list.add(new MyMacro());
      list.add(new MyModifyer());
      return list;
   }
}
```

The following plugin directive will then register both MyMacro and MyModifyer.

```
.plugin "test.plugins.archives.MyArchive"
```

Appendix A. Quick Reference

A.1. Command Line Options

Table A.1. Command Line Options

Option	Example	Description
-o	-o dots.prg	Sets the output file. Default is the input filename with a '.prg' as suffix.
-libdir	-libdir ../stdLib	Defines a library where the assembler will look when it tries to open external files.
-showmem	-showmem	Show a memory map after assembling.
-execute	-execute "x64 +sound"	Execute a given program with the assembled file as argument. You can use this to start a C64 emulator with the assembled program if the assembling is successful.
-warningsoff	-warningsoff	Turns off warning messages.
-log	-log logfile.txt	Prints the output of the assembler to a logfile.
-dtv	-dtv	Enables DTV opcodes.
-aom	-aom	Allow overlapping memory blocks. With this option, overlapping memory blocks will produce a warning instead of an error.
-time	-time	Displays the assemble time.
-vicesymbols	-vicesymbols	Generates a label file for VICE.
-binfile	-binfile	Sets the output to be a bin file instead of a prg file. The difference between a bin and a prg file is that the bin file doesn't contain the two start address bytes.
-afo	-afo	Allows file output to user defined files
:name=value	:x=34 :version=beta2 :path="c:/C64/"	The ':' notation denotes string variables passed to the script. They can be accessed by using the 'cmdLineVars' hashtable which is available from the script.
-symbolfile	-symbolfile	Genrates a .sym file with the resolved symbols. The file can be used in other sources with the .import source directive.
-symbolfiledir	-symbolfiledir sources/symbolfiles	Specifies the folder in which the symbolfile is written. If none is given, its written next to the sourcefile.
-fillbyte	-fillbyte 255	Sets the byte used to fill the space between memoryblocks in the prg file.

Option	Example	Description
-maxaddr	-maxaddr 8191	Sets the upper limit for the memory, default is 65535. Setting a negative value means unlimited memory.
-mbfiles	-mbfiles	One file will be saved for each memory block instead of one big file.

A.2. Assembler Directives

Will come later..

A.3. Value Types

Will come later...

Appendix B. Technical Details

In Kick Assembler 3 some rather advanced techniques have been implemented to make the assembling more flexible and correct. I'll describe some of the main points here. YOU DON'T NEED TO KNOW THIS, but if you are curious about technical details then read on.

B.1. The flexible Parse Algorithm

Kick Assembler 3 uses a flexible pass algorithm, which parses each assembler command or directive as much as possible in each pass. Some commands can be finished in first pass, such as lda #10 or sta $1000. But if a command depends on information not yet given, like ‘jmp routine’ where the routine label hasn't been defined yet, an extra pass is required. Kick Assembler keeps executing passes until the assembling is finished or no progress has been made. You can write programs that only need one pass, but most programs will need two or more. This approach is more flexible and gives advantages over normal fixed pass assembling. All directives don't have to be in the same phase of assembling, which gives some nice possibilities for future directives.

B.2. Recording of Side Effects

Side effects of directives are now recorded and replayed the subsequent passes. Consider the following eval directive: .eval a=[5+8/2+1]*10.In the first pass the calculation [5+8/2 + 1]*10 will be executed and find the result 100, which will be assigned to a. In the next pass no calculation is done, only the side effect (a=100) is executed. This speeds up programs with heavy scripting, since the script only has to execute once.

B.3. Function Mode and Asm Mode

Kick assembler has two modes for executing directives. ‘Function Mode’ is used when the directive is placed inside a function or .define directive, otherwise ‘Asm Mode’ is used. ‘Function Mode’ is executed fast but is restricted to script commands only (.var, .const, .for, etc.), while ‘Asm Mode’ can handle all directives and records the side effects as described in previous section. All evaluation starts in ‘Asm Mode’ and enters ‘Function Mode’ if you get inside the body a function or .define directive. This means that at some point there is always a directive that records the result of the evaluation.

B.4. Invalid Value Calculations

Invalid values occur when the information used to calculate a value that isn't available yet. Usually this starts with an unresolved label value, which is defined later in the source code. Normally you would stop assembling the current directive once you reach an invalid value, but that might leave out some side effects you did intend to happen, so instead of stopping, the assembler now carries on operating on the invalid values. So an unresolved label is just an unresolved Number value. If you add two number values and one of them is invalid then the result will be another invalid number value. If you compare two invalid numbers then you get an invalid boolean and so forth. This helps to track down which values to invalidate. If for example you use an invalid number as index in a set function on a list, you must invalidate the whole list since you don't know which element is overwritten. Some examples of invalid value calculations:

```
4+InvalidNumber -> InvalidNumber
InvalidNumber != 5 ->  InvalidBoolean
myList.set(3, InvalidNumber) -> [?,?,InvalidNumber]
myList.set(InvalidNumber, “Hello”) -> InvalidList
myList.set(4+4*InvalidNumber, “Hello”) -> InvalidList
```