C64 Assembly and PowerShell

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Contents

Chapter 00 - Prologue

This will be a book about C64 Assembly programming that includes a deep dive into 6502 opcodes, C64 VICII, Basic and Kernal information and how I built a 6502 assembler in PowerShell.

Revision History

20230624 - First Update

Chapter XX - Assembly Routines

@BASICSTUB()

Macro Definition

```
#MACRO BASICSTUB()
            ; Basic Stub
            ; 10 SYS2061
            DATA        $080B   ; Pointer to Next Line
            DATA        $000A   ; Line Number '10'
            DATA.B      $9E     ; BASIC Token for SYS
            DATA.B      $32     ; '2'
            DATA.B      $30     ; '0'
            DATA.B      $36     ; '6'
            DATA.B      $31     ; '1'  - 2061 is $080D
            DATA.B      $00     ; End of current line
            DATA        $0000   ; Next Line (NULL no more lines)
#ENDM
```

Assembly Code

```
* = $0801

#INCLUDE ..\includes\includes.h

@BASICSTUB()

START:              LDA.#   $01
                    STA     VICII_SCREEN_RAM
                    RTS
```

Assembly Command

```
..\..\source\PSAssembler.ps1 .\basicstub.asm -GenerateLST -ExecutePRG
```

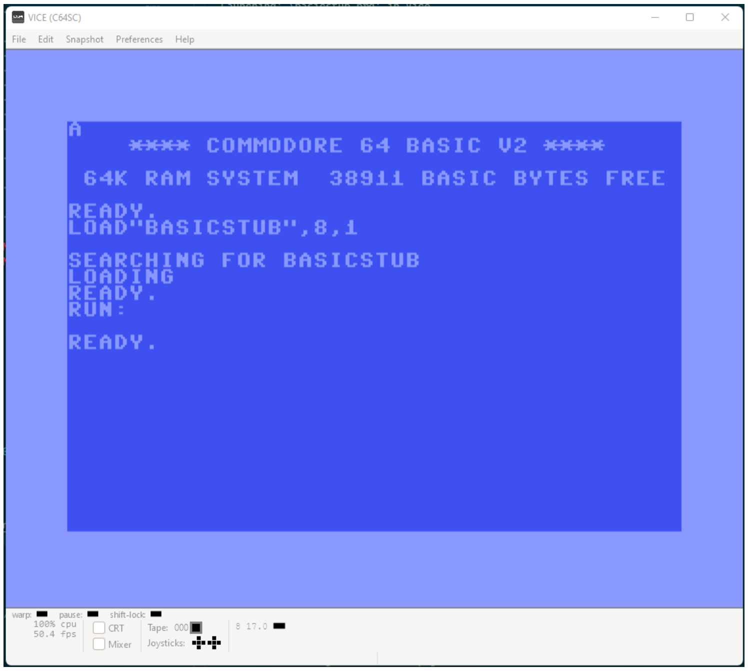
Output

```
08:52:23 : Starting Assembly...
08:52:23 : Loading file '.\basicstub.asm'
08:52:23 : Loading file '.\..\includes\includes.h'
08:52:23 : Loading file '.\..\includes\zeropage.h'
08:52:23 : Loading file '.\..\includes\vicii.h'
08:52:23 : Loading file '.\..\includes\cia.h'
08:52:23 : Loading file '.\..\includes\vicii_macros.h'
08:52:23 : Loading file '.\..\includes\basicstub.h'
08:52:23 : Loading file '.\..\includes\macros.h'
08:52:23 : Executing Code
08:52:23 : Expanding Macros Pass #1
08:52:23 : Expanding Macros Pass #2
08:52:23 : Assembly Pass => Collection
08:52:23 : Assembly Pass => Allocation
08:52:24 : Assembly Pass => Optimization
08:52:24 : Assembly Pass => Relocation
08:52:24 : Assembly Pass => Assembly
08:52:24 : Completed Assembly...
0801 |          |             | * = $0801
0801 |          |             |
0801 |          |             | #INCLUDE ..\includes\includes.h
0801 |          |             |             ; Basic Stub
0801 |          |             |             ; 10 SYS2061
0801 | 0B 08    |             |             DATA        $080B   ; Pointer to Next Line
0803 | 0A 00    |             |             DATA        $000A   ; Line Number '10'
```

```
0805 | 9E       |             |             DATA.B      $9E      ; BASIC Token for SYS
0806 | 32       |             |             DATA.B      $32      ; '2'
0807 | 30       |             |             DATA.B      $30      ; '0'
0808 | 36       |             |             DATA.B      $36      ; '6'
0809 | 31       |             |             DATA.B      $31      ; '1'  - 2061 is $080D
080A | 00       |             |             DATA.B      $00      ; End of current line
080B | 00 00    |             |             DATA        $0000    ; Next Line (NULL no more lines)
080D |          |             |
080D | A9 01    | LDA #$01    | START:              LDA.#   $01
080F | 8D 00 04 | STA $0400   |                     STA     VICII_SCREEN_RAM
0812 | 60       | RTS         |                     RTS
Assembly Report:
   Assembly Start  : 6/24/2023 8:52:23 AM
   Assembly End    : 6/24/2023 8:52:24 AM
   Elapsed Seconds : 0.61
   Loaded Lines    : 352
   Loaded Bytes    : 0
   Assembled Lines : 12
   Assembled Bytes : 18
   Total Bytes     : 18
   Starting Address: $0801
   Ending Address  : $0813
   Labels/Variables: 125
   Macros          : 27
   Optimized Out   : 0
08:52:24 : Writing '.\basicstub.prg'
   Wrote to '.\basicstub.prg' in 0.0029457 seconds.
Launching'.\basicstub.prg' in Vice.
```

Running in Vice

Here is this simplest (well it could be simpler but then there would be no discernable change to C64 to verify that it actually ran some custom assembly) assembly programming running in vice:



```
A
    **** COMMODORE 64 BASIC V2 ****

 64K RAM SYSTEM  38911 BASIC BYTES FREE

READY.
LOAD"BASICSTUB",8,1

SEARCHING FOR BASICSTUB
LOADING
READY.
RUN:

READY.
```

Binary to BinaryCodedDecimal

General Information

8 Bit

This example has the #STATS commands to show how the statistics are calculated:

Assemblu

```
#STATS.PUSH
BINARY_TO_BCD_8:
                LDA.#   0           ; Clear the Result
                STA     .RESULT
                STA     .RESULT + 1
                SED                 ; Set decimal mode
                LDX.#   8           ; The number of source bits

#STATS.PUSH
.LOOP:          ASL     .NUMBER     ; Shift out one bit
                LDA     .RESULT     ; And add into result
                ADC     .RESULT
                STA     .RESULT
                LDA     .RESULT + 1
                ADC     .RESULT + 1
                STA     .RESULT + 1
                DEX                 ; And repeat for next bit
                BNE     .LOOP
#STATS.LOOP 8
#STATS.POP
                CLD                 ; Clear decimal mode
                RTS
.NUMBER:        DATA.b  $FF
.RESULT:        PAD     2
#STATS.DETAIL
#STATS.SAVE BINARY_TO_BCD_8
#STATS.POP
```

Stats

```
Stat: 'BINARY_TO_BCD_8'
   Bytes: 40   MinCycles: 274   MaxCycles: 290
   MinCycleTime: .27 mSec   MaxCycleTime: .28 mSec
   Max FPS: 3,722.63   Min FPS: 3,517.24
```

16 Bit

Assembly

```
BINARY_TO_BCD_16:
                LDA.#   0       ; Clear the Result
                STA     .RESULT
                STA     .RESULT + 1
                STA     .RESULT + 2
                SED                 ; Set decimal mode
                LDX.#   16      ; The number of source bits

.LOOP:          ASL     .NUMBER     ; Shift out one bit
                ROL     .NUMBER + 1
                LDA     .RESULT        ; And add into result
                ADC     .RESULT
                STA     .RESULT
                LDA     .RESULT + 1
                ADC     .RESULT + 1
                STA     .RESULT + 1
                LDA     .RESULT + 2
                ADC     .RESULT + 2
                STA     .RESULT + 2
                DEX                 ; And repeat for next bit
                BNE     .LOOP
                CLD                 ; Clear decimal mode
                RTS
.NUMBER:        DATA    $FFFF
.RESULT:        PAD     3
```

Stats

```
Stat: 'BINARY_TO_BCD_16'
   Bytes: 57   MinCycles: 790   MaxCycles: 822
   MinCycleTime: .77 mSec   MaxCycleTime: .81 mSec
   Max FPS: 1,291.14   Min FPS: 1,240.88
```

24 Bit

Assembly

```
BINARY_TO_BCD_24:
                LDA.#   0       ; Clear the Result
                STA     .RESULT
                STA     .RESULT + 1
                STA     .RESULT + 2
                STA     .RESULT + 3
                SED                 ; Set decimal mode
                LDX.#   24      ; The number of source bits

.LOOP:          ASL     .NUMBER     ; Shift out one bit
                ROL     .NUMBER + 1
                ROL     .NUMBER + 2
                LDA     .RESULT ; And add into result
                ADC     .RESULT
                STA     .RESULT
                LDA     .RESULT + 1 ; propagating any carry
                ADC     .RESULT + 1
                STA     .RESULT + 1
                LDA     .RESULT + 2 ; propagating any carry
                ADC     .RESULT + 2
                STA     .RESULT + 2
                LDA     .RESULT + 3 ; propagating any carry
                ADC     .RESULT + 3
                STA     .RESULT + 3
                DEX     ; And repeat for next bit
                BNE     .LOOP

                CLD                 ; Clear decimal mode
                RTS
.NUMBER:        DATA    $FFFF
                DATA.b  $FF
.RESULT:        PAD     4
```

Stats

```
Stat: 'BINARY_TO_BCD_24'
   Bytes: 74   MinCycles: 1,562   MaxCycles: 1,610
   MinCycleTime: 1.53 mSec   MaxCycleTime: 1.58 mSec
   Max FPS: 653.01   Min FPS: 633.54
```

32 Bit

Assembly

```
BINARY_TO_BCD_32:
                LDA.#   0       ; Ensure the result is clear
                STA     .RESULT
                STA     .RESULT + 1
                STA     .RESULT + 2
                STA     .RESULT + 3
                STA     .RESULT + 4
                SED                 ; Set decimal mode
                LDX.#   32      ; The number of source bits

.LOOP:          ASL     .NUMBER     ; Shift out one bit
                ROL     .NUMBER + 1
                ROL     .NUMBER + 2
                ROL     .NUMBER + 3
                LDA     .RESULT ; And add into result
                ADC     .RESULT
                STA     .RESULT
                LDA     .RESULT + 1 ; propagating any carry
                ADC     .RESULT + 1
                STA     .RESULT + 1
                LDA     .RESULT + 2 ; propagating any carry
                ADC     .RESULT + 2
                STA     .RESULT + 2
                LDA     .RESULT + 3 ; propagating any carry
                ADC     .RESULT + 3
                STA     .RESULT + 3
                LDA     .RESULT + 4 ; propagating any carry
                ADC     .RESULT + 4
                STA     .RESULT + 4
                DEX     ; And repeat for next bit
                BNE     .LOOP

                CLD                 ; Clear decimal mode
                RTS
.NUMBER:        DATA    $FFFF
                DATA    $FFFF
.RESULT:        PAD     5
```

Stats

```
Stat: 'BINARY_TO_BCD_32'
   Bytes: 91   MinCycles: 2,714   MaxCycles: 2,778
   MinCycleTime: 2.66 mSec   MaxCycleTime: 2.72 mSec
   Max FPS: 375.83   Min FPS: 367.17
```

Example

```
START:
                    LDX.#   $10         ; Loop for 16 times...
.LOOP:
                    LDA,X   $1000
                    STA,X   $2000
                    DEX
                    BPL     .LOOP
```