C256 – Developer Introduction Notes

# Introduction to the C256 System

## Hardware

The C256 system uses a 65C816 micro-processor.

System clock is 14MHz.

Power supply required is +12V 1A with a 2.5mm plug.

Keyboard requires a PS/2 connector.

Figure 1 provides several more details about the Rev B board.



Figure - Revision B Board Specification

# Contributing to the IDE Development

## Git Repositories

* Foenix IDE: <https://github.com/Trinity-11/FoenixIDE.git>
* C256 Kernel (Rev B): <https://github.com/Trinity-11/Kernel>
* FMX Kernel (Rev C): <https://github.com/Trinity-11/Kernel_FMX>

## Tools

To modify the Foenix IDE, you will need Visual Studio 2017 Community edition for C#.

# Using the Foenix IDE

The Integrated Development Environment consists of a 65816 emulator and a C256 Foenix memory map emulator.

## Launching the Application

To start the IDE, double-click on the FoenixIDE icon  or using a console, type “FoenixIDE.exe”.

The command-line accepts three parameters:

-h, --hex: load the program into memory for an “Intel Hex” file format;

-r, --run: auto-run the provided binary; and

-i, --irq: disable “break on interrupts” in the CPU window.

-b: board revision “b” or “c”.

If no parameters are specified the application will launch with defaults:

* Program is loaded from ROMS\kernel.hex; if it doesn’t exist, the user is prompted to select one using the Windows File Dialog;
* Autorun is disabled; and
* Break on Interrupts is enabled.

## IDE Windows

The IDE consists of three main windows. The display, the CPU debugger and the memory editor.

# Understanding the C256 Foenix

The Foenix IDE currently emulates the C256 Foenix computer Revisions B and C. To switch between the two modes, click on the Revision selection box on the Toolstip, as shown in Figure 1 below.

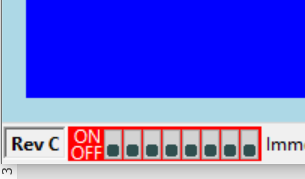


Figure - Revision Selection Box

## Memory Map

The CPU can access 24-bit worth of addresses.



|  |  |  |
| --- | --- | --- |
| $FF:0000 - $FF:FFFF | Bank $FF | **16 MB Address Space** |
| $FE:0000 - $FE:FFFF | Bank $FE |
|  |  |
|  |  |
|  |  |
|  |  |
| $00:0000 - $01:FFFF | Bank $01 |
| $00:0000 - $00:FFFF | Bank $00 |

The address space is mapped as follows:

|  |  |
| --- | --- |
| $F8:0000 - $FF:FFFF | 512 KB User Flash (if populated) |
| $F0:0000 - $F7:FFFF | 512 KB System Flash |
| $B0:0000 - $EF:FFFF | 4 MB Video RAM |
| $AF:0000 - $AF:FFFF | IO Space |
| $40:0000 - $AE:FFFF | Extension Card |
| $20:0000 - $3F:FFFF | 2 MB RAM (optional in Rev B) |
| $00:0000 - $1F:FFFF | 2 MB RAM |

On boot, Gavin copies the first 64KB of the content of System Flash (or User Flash, if present) to Bank $00. The entire 512KB are copied to address range $18:0000 to $1F:FFFF.

IO Space is mapped to Vicky: $AF:0000 to $AF:DFFF and Beatrix: $AF:E000 to $AF:FFFF.

### Gavin – Location $00:0000 to $00:FFFF



#### Math Co-Processor

The C256 provides a math co-processor to perform long addition, multiplications and divisions of integers. The FMX version of the board also provides floating-point capabilities.

To perform an operation, you write the little-endian values in the appropriate address locations and the results are automatically returned in the result addresses.

##### Integer Multiplications

There are two multiplier locations: $00:0100 and $00:0108. Multiplier 0 is unsigned and Multiplier 1 is signed. Each operand must be 16-bits, and the result is 32-bits.

|  |  |  |
| --- | --- | --- |
| **Address** | **Name** | **Description** |
| $00:0100 | M0\_OPERAND\_A | 16-bit unsigned value |
| $00:0102 | M0\_OPERAND\_B | 16-bit unsigned value |
| $00:0104 | M0\_RESULT | 32-bit unsigned result of the multiplication of A and B |

|  |  |  |
| --- | --- | --- |
| **Address** | **Name** | **Description** |
| $00:0108 | M1\_OPERAND\_A | 16-bit signed value |
| $00:010A | M1\_OPERAND\_B | 16-bit signed value |
| $00:010C | M1\_RESULT | 32-bit signed result of the multiplication of A and B |

##### Integer Divisions

There are two divider locations: $00:0110 and $00:0118. Divider 0 is unsigned and Divider 1 is signed. Each operand must be 16-bits. The result and remainder are 16-bits also.

|  |  |  |
| --- | --- | --- |
| **Address** | **Name** | **Description** |
| $00:0110 | D0\_OPERAND\_A | 16-bit unsigned value for the dividend |
| $00:0112 | D0\_OPERAND\_B | 16-bit unsigned value for the divisor |
| $00:0114 | D0\_RESULT | 16-bit unsigned result for the quotient |
| $00:0116 | D0\_REMAINDER | 16-bit unsigned result for the remainder |

|  |  |  |
| --- | --- | --- |
| **Address** | **Name** | **Description** |
| $00:0118 | D1\_OPERAND\_A | 16-bit signed value for the dividend |
| $00:011A | D1\_OPERAND\_B | 16-bit signed value for the divisor |
| $00:011C | D1\_RESULT | 16-bit signed result for the quotient |
| $00:011E | D1\_ REMAINDER | 16-bit signed result for the remainder |

##### Long Signed Additions

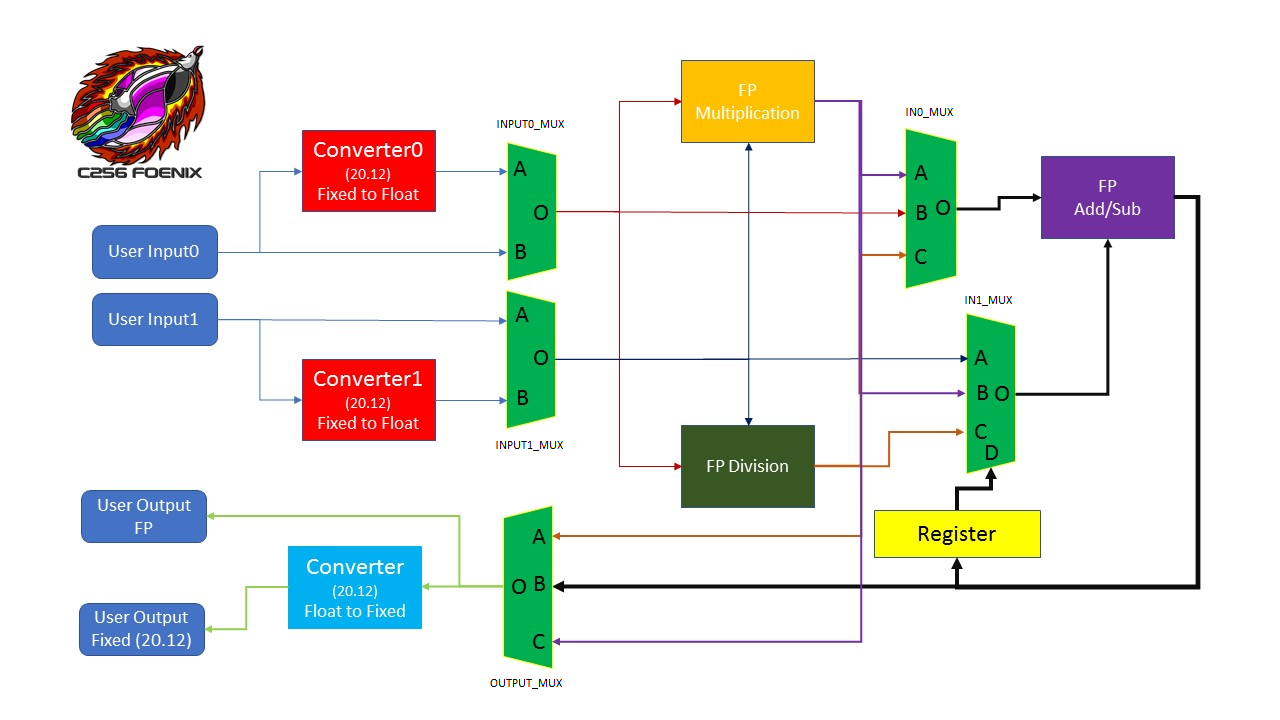
There is one long signed adder located at $00:0120. Both operands must be 32-bit signed integers. The result is also 32-bit signed.

|  |  |  |
| --- | --- | --- |
| **Address** | **Name** | **Description** |
| $00:0120 | ADDER32\_A | 32-bit signed value |
| $00:0124 | ADDER32\_B | 32-bit signed value |
| $00:0128 | ADDER32\_R | 32-bit signed result of the addition of A and B |

#### Floating Point Capability

Users can provide input data as fixed precision values (20.12) or IEEE-754 values. All operations inside the Floating Point processor use IEEE-754 values. Output values can be returned as 20.12 or IEEE-754 values.

|  |  |  |
| --- | --- | --- |
| **Address** | **Name** | **Description** |
| $AF:E200 | FP\_MATH\_CTRL0 | Input multiplexer register |
| $AF:E201 | FP\_MATH\_CTRL1 | Output multiplexer register |
| $AF:E204 | FP\_MATH\_MULT\_STAT | Multiplication Status (Read-Only) |
| $AF:E205 | FP\_MATH\_DIV\_STAT | Division Status (Read-Only) |
| $AF:E206 | FP\_MATH\_ADD\_STAT | Addition Status (Read-Only) |
| $AF:E207 | FP\_MATH\_CONV\_STAT | Conversion Status (Read-Only) |
| $AF:E208 | FP\_MATH\_INPUT0 (W)  FP\_MATH\_OUTPUT\_FP (R) | Input Value 0 Little-Endian 4 bytes - FP or Fixed (20.12) |
| $AF:E20C | FP\_MATH\_INPUT1 (W)  FP\_MATH\_OUTPUT\_FIXED (R) | Input Value 1 Little-Endian 4 bytes - FP or Fixed (20.12) |



|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **FP\_MATH\_CTRL0 ($AF:E200)** | | | | | | | |
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| IN1\_MUX | | IN0\_MUX | | ADD\_SUB | Reserved | INPUT1\_MUX | INPUT0\_MUX |
| 00: Input Mux0  01: Input Mux1  10: Mult Out  11: Div Out | | 00: Input Mux0  01: Input Mux1  10: Mult Out  11: Div Out | | 0: Subtraction  1: Addition | N/A | 0: User Input  1: Convert Fixed to FP | 0: User Input  1: Convert Fixed to FP |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **FP\_MATH\_CTRL1 ($AF:E201)** | | | | | | | |
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Reserved | Reserved | Reserved | Reserved | Reserved | Reserved | OUTPUT\_MUX | |
| N/A | N/A | N/A | N/A | N/A | N/A | 00: Mult Output  01: Div Output  10: Add/Subtract Output  11: '1' | |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **FP\_MATH\_MULT\_STAT ($AF:E204)** | | | | | | | |
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Reserved | Reserved | Reserved | Reserved | ZERO | UDF | OVF | NAN |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **FP\_MATH\_DIV\_STAT ($AF:E205)** | | | | | | | |
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Reserved | Reserved | Reserved | DIVBYZERO | ZERO | UDF | OVF | NAN |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **FP\_MATH\_ADD\_STAT ($AF:E206)** | | | | | | | |
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Reserved | Reserved | Reserved | Reserved | ZERO | UDF | OVF | NAN |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **FP\_MATH\_CONV\_STAT ($AF:E207)** | | | | | | | |
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Reserved | Reserved | Reserved | Reserved | Reserved | UDF | OVF | NAN |

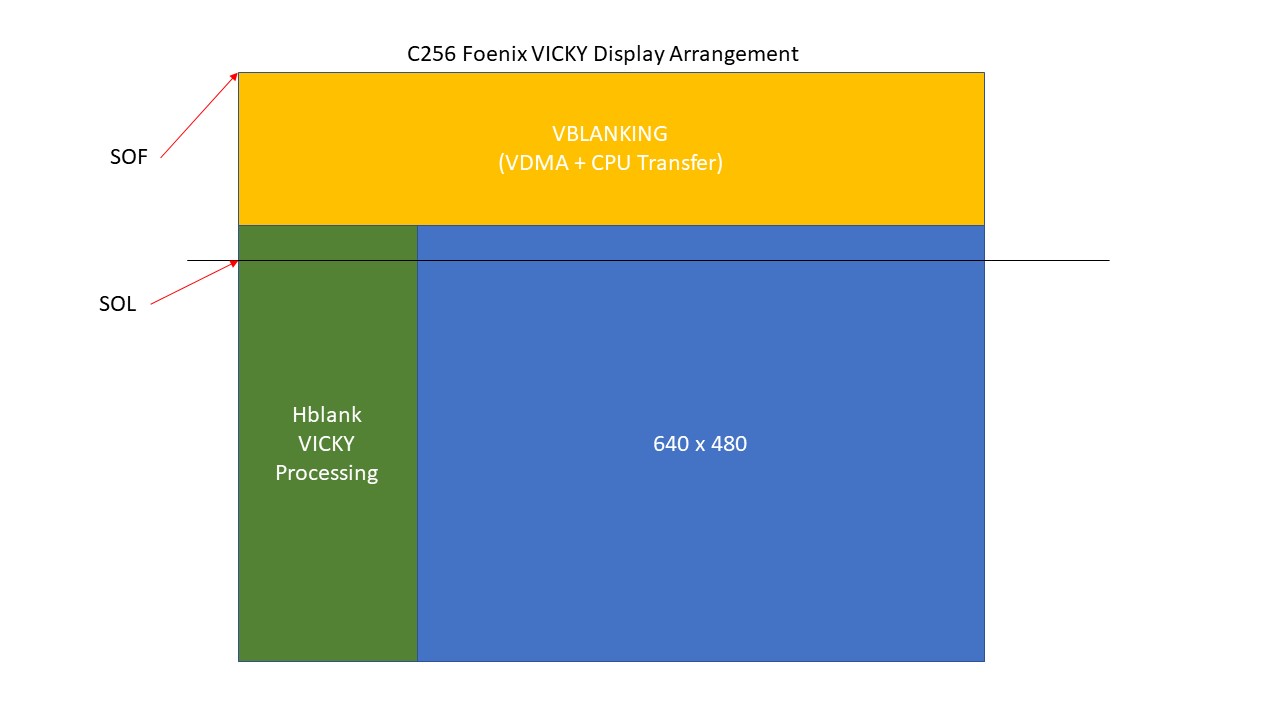
### Interrupt Controller

|  |  |  |
| --- | --- | --- |
| **Address** | **Name** | **Description** |
| $00:0140 | INT\_PENDING\_REG0 | Pending Interrupts Register 0 |
| $00:0141 | INT\_PENDING\_REG1 | Pending Interrupts Register 1 |
| $00:0142 | INT\_PENDING\_REG2 | Pending Interrupts Register 2 |
| $00:0143 | INT\_PENDING\_REG3 | Pending Interrupts Register 3 (FMX only) |
| $00:0144 | INT\_POL\_REG0 | Polarity Set Interrupts Register 0 |
| $00:0145 | INT\_POL\_REG1 | Polarity Set Interrupts Register 1 |
| $00:0146 | INT\_POL\_REG2 | Polarity Set Interrupts Register 2 |
| $00:0147 | INT\_POL\_REG3 | Polarity Set Interrupts Register 3 (FMX only) |
| $00:0148 | INT\_EDGE\_REG0 | Edge Interrupts Register 0 |
| $00:0149 | INT\_EDGE\_REG1 | Edge Interrupts Register 1 |
| $00:014A | INT\_EDGE\_REG2 | Edge Interrupts Register 2 |
| $00:014B | INT\_EDGE\_REG3 | Edge Interrupts Register 3 (FMX only) |
| $00:014C | INT\_MASK\_REG0 | Interrupt Masks Register 0 |
| $00:014D | INT\_MASK\_REG1 | Interrupt Masks Register 1 |
| $00:014E | INT\_MASK\_REG2 | Interrupt Masks Register 2 |
| $00:014F | INT\_MASK\_REG3 | Interrupt Masks Register 3 (FMX only) |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Interrupt Register 0 ($00:0140, $00:0144, $00:0148, $00:014C)** | | | | | | | |
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Mouse | Floppy Disk | RTC | Timer 2 | Timer 1 | Timer 0 | SOL | SOF |

Description

|  |  |
| --- | --- |
| SOF | Start of Frame – 60 Frames per Second (FPS) |
| SOL | Start of Line – 60 FPS offset |
| RTC | Clock Alarm, etc..., See the chip spec for more detail for the registers: BQ4802 |



|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Interrupt Register 1 ($00:0141, $00:0145, $00:0149, $00:014D)** | | | | | | | |
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| SDCARD | LPT1 | MPU-401 | COM1 | COM2 | Tile Coll | Sprite Coll | Keyboard |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Interrupt Register 2 ($00:0142, $00:0146, $00:014A, $00:014E) – Rev B** | | | | | | | |
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Always 1 | Expansion | DAC | Video DMA | Gavin DMA | Beatrix | OPL2 Left | OPL2 Right |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Interrupt Register 2 ($00:0142, $00:0146, $00:014A, $00:014E) – Rev C (FMX)** | | | | | | | |
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| SD Card Insertion | Expansion | Gabe Int2 | Vicky II Int5 | Vicky II Int4 | Gabe Int1 | Gabe Int0 | OPL3 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Interrupt Register 3 ($00:0143, $00:0147, $00:014B, $00:014F) – Rev C (FMX) only** | | | | | | | |
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| SD Card Insertion | Expansion | Gabe – TBD | TBD | TBD | HDD IDE IRQ | OPM | OPN2 |

### Vicky – Location $AF:0000 to $AF:DFFF



#### Vicky Memory

|  |
| --- |
| $AF:0000 - $AF:00FF (Internal Memory) Vicky General Registers |
| BORDER\_COLOR\_B = $AF:0005 - when in text mode, this is the border color shown.  BORDER\_COLOR\_G = $AF:0006  BORDER\_COLOR\_R = $AF:0007 |
| When in Graphic Mode, if a pixel is "0" then the Background pixel is chosen  BACKGROUND\_COLOR\_B = $AF:000D  BACKGROUND\_COLOR\_G = $AF:000E  BACKGROUND\_COLOR\_R = $AF:000F |
| $AF:0100 - $AF:013F (Internal Memory) Vicky Tiles Registers |
| $AF:0140 - $AF:014F (Internal Memory) Vicky Bitmap Registers |
| $AF:0200 - $AF:03FF (Internal Memory) Vicky Sprites |
| $AF:0400 - $AF:04FF (Internal Memory) Vicky VDMA |
| $AF:0800 - $AF:080F Real-time clock (RTC) |

#### Video Direct Memory Access

Memory Address Range reserved: DMA Controller $AF0400 - $AF04FF

VDMA\_CONTROL\_REG = $AF0400

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **VDMA Control Register ($AF:0400)** | | | | | | | |
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Start Tfr | - | - | - | IRQ Enable | Fill | 2D | Enable |

Description

|  |  |
| --- | --- |
| VDMA\_CTRL\_Enable | Enable the VDMA Transfer |
| VDMA\_CTRL\_1D\_2D | 0 - 1D (Linear) Transfer , 1 - 2D (Block) Transfer |
| VDMA\_CTRL\_TRF\_Fill | 0 - Transfer Src -> Dst, 1 - Fill Destination with "Byte2Write" |
| VDMA\_CTRL\_Int\_Enable | Set to 1 to Enable the Generation of Interrupt when the Transfer is over |
| VDMA\_CTRL\_Start\_TRF | Set to 1 To Begin Process, Need to Cleared before, you can start another |

VDMA\_BYTE\_2\_WRITE = $AF0401 ; Write Only - Byte to Write in the Fill Function

VDMA\_STATUS\_REG = $AF0401 ; Read only

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **VDMA Status Register ($AF:0401) – Read-only** | | | | | | | |
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Tfr In Progress | - | - | - | - | Invalid Src Addr | Invalid Dest Addr | Size Error |

When Transfer is in Progress, the CPU will not be able to access Video Memory.

VDMA\_SRC\_ADDY\_L = $AF0402 ; Pointer to the Source of the Data to be transferred

VDMA\_SRC\_ADDY\_M = $AF0403 ; This needs to be within Vicky's Range ($00:0000 - $3F:0000)

VDMA\_SRC\_ADDY\_H = $AF0404

VDMA\_DST\_ADDY\_L = $AF0405 ; Destination Pointer within Vicky's video memory Range

VDMA\_DST\_ADDY\_M = $AF0406 ; ($00:0000 - $3F:0000)

VDMA\_DST\_ADDY\_H = $AF0407

In 1D Transfer Mode, specify how many bytes to transfer. Maximum value is $40:0000 or 4 megabytes.

VDMA\_SIZE\_L = $AF0408

VDMA\_SIZE\_M = $AF0409

VDMA\_SIZE\_H = $AF040A

VDMA\_IGNORED = $AF040B

In 2D Transfer Mode, specify the width and height to transfer. Maximum is 65,536 in each direction.

VDMA\_X\_SIZE\_L = $AF0408 ; Maximum Value: 65535

VDMA\_X\_SIZE\_H = $AF0409

VDMA\_Y\_SIZE\_L = $AF040A ; Maximum Value: 65535

VDMA\_Y\_SIZE\_H = $AF040B

VDMA\_SRC\_STRIDE\_L = $AF040C ; Always use an Even Number ( The Engine uses Even Ver of that value)

VDMA\_SRC\_STRIDE\_H = $AF040D ;

VDMA\_DST\_STRIDE\_L = $AF040E ; Always use an Even Number ( The Engine uses Even Ver of that value)

VDMA\_DST\_STRIDE\_H = $AF040F ;

|  |
| --- |
| $AF:1000 - $AF:13FF - SUPER IO Devices --- (TOTAL USAGE) --- |
| // Super IO Details: |
| // $AF:1060 - $AF:1064 - LOGIC DEVICE 7 - KEYBOARD |
| // $AF:1100 - $AF:117F - LOGIC DEVICE A - PME (Runtime Registers) |
| // $AF:1200 - $AF:1200 - LOGIC DEVICE 9 - GAME PORT |
| // $AF:12F8 - $AF:12FF - LOGIC DEVICE 5 - SERIAL 2 |
| // $AF:1330 - $AF:1331 - LOGIC DEVICE B - MPU-401 |
| // $AF:1378 - $AF:137F - LOGIC DEVICE 3 - PARALLEL PORT |
| // $AF:13F0 - $AF:13F7 - LOGIC DEVICE 0 - FLOPPY CONTROLLER |
| // $AF:13F8 - $AF:13FF - LOGIC DEVICE 4 - SERIAL 1 |

$AF:1F00 - $AF:1F3F (Internal Memory) Vicky Text Mode 16 Color Look-up Table Foreground Color

$AF:1F40 - $AF:1F7F (Internal Memory) Vicky Text Mode 16 Color Look-up Table Background Color

$AF:2000 - $AF:23FF (Internal Memory) Graphic Mode LUT0

$AF:2400 - $AF:27FF (Internal Memory) Graphics Mode LUT1

$AF:2800 - $AF:2BFF (Internal Memory) Graphics Mode LUT2

$AF:2C00 - $AF:2FFF (Internal Memory) Graphics Mode LUT3

$AF:4000 - $AF:40FF (External Memory) 256 Bytes GAMMA LUT - RED

$AF:4100 - $AF:41FF (External Memory) 256 Bytes GAMMA LUT - GREEN

$AF:4200 - $AF:42FF (External Memory) 256 Bytes GAMMA LUT – BLUE

FONT\_MEMORY\_BANK0 = $AF:8000 - $AF:8FFF

FONT\_MEMORY\_BANK1 = $AF:9000 - $AF:9FFF

#### Screen Page 0 – Location $AF:A000

Screen Page 0 memory is used to store text characters for display.

One page of text is 128 columns by 64 rows. This adds up to 8 KB of memory of text. C256 does not display the entire buffer on the screen. Typically, we render 72 characters per row, with 56 rows.

This uses 576 x 448 of the available 640 x 480 resolution. The border size can be modified or turned off completely.

The display process reads Screen Page 0 and for each character, displays it’s character set bitmap.

#### Screen Page 1 – Location $AF:C000

An additional page of 128 x 64 is used to store the colors. Each byte is split into foreground (4bits) and background (4 bits). The high nibble (bits 7..4) are the foreground and the low nibble (bits 3..0) are the background.

The colors used (the 4 bits) are used to lookup RBG values in two lookup tables (LUT).

The foreground (FG) LUT is located at $AF:1F40 for 64 bytes – only 16 x 3 = 48 bytes are used. The extra byte may be used for alpha (transparency) later on.

The background (BG) LUT is located at $AF:1F80 for 64 bytes – only 16 x 3 = 48 bytes are used. The extra byte may be used for alpha (transparency) later on.

The colors are assigned 8-bit blue, 8-bit green, 8-bit red, 8-bit alpha (not used) for each of those colors in Text Mode.

##### Example – Color Lookup

Consider the following Foreground and Background Lookup Tables

|  |  |
| --- | --- |
| Foreground Color Lookup Table, starting at address $AF:1F40 | Background Color Lookup Table, starting at address $AF:1F80 |
| |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | Index | Blue | Green | Red | Alpha | Color | | 0 | $00 | $00 | $00 | $FF | Black | | 1 | $00 | $00 | $80 | $FF | Maroon | | 2 | $00 | $80 | $00 | $FF | Green | | 3 | $80 | $00 | $00 | $FF | Navy | | 4 | $00 | $80 | $80 | $FF | Olive | | 5 | $80 | $80 | $00 | $FF | Teal | | 6 | $80 | $00 | $80 | $FF | Purple | | 7 | $80 | $80 | $80 | $FF | Gray | | 8 | $00 | $45 | $FF | $FF | Orange | | 9 | $13 | $45 | $8B | $FF | Brown | | A | $00 | $00 | $20 | $FF | Dark Red | | B | $00 | $20 | $00 | $FF | Dark Green | | C | $20 | $00 | $00 | $FF | Indigo | | D | $20 | $20 | $20 | $FF | Dark Gray | | E | $40 | $40 | $40 | $FF | Slate Gray | | F | $FF | $FF | $FF | $FF | White | | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | Index | Blue | Green | Red | Alpha | Color | | 0 | $00 | $00 | $00 | $FF | Black | | 1 | $00 | $00 | $80 | $FF | Maroon | | 2 | $00 | $80 | $00 | $FF | Green | | 3 | $80 | $00 | $00 | $FF | Navy | | 4 | $00 | $20 | $20 | $FF | ?? | | 5 | $20 | $20 | $00 | $FF | ?? | | 6 | $20 | $00 | $20 | $FF | ?? | | 7 | $20 | $20 | $20 | $FF | ?? | | 8 | $1E | $69 | $D2 | $FF |  | | 9 | $13 | $45 | $8B | $FF | Brown | | A | $00 | $00 | $20 | $FF | Dark Red | | B | $00 | $20 | $00 | $FF | Dark Green | | C | $40 | $00 | $00 | $FF | Blue | | D | $10 | $10 | $10 | $FF | Midnight Gray | | E | $40 | $40 | $40 | $FF | Slate Gray | | F | $FF | $FF | $FF | $FF | White | |

If a character in Screen Page 1 is $ED (the default text color combination), then the foreground color index is E and the background color index is D. Looking up the index for E will make the foreground “Slate Gray” and the background “Midnight Gray”. The image below shows this color combination in text.



#### Text Gamma Lookup Table

The Gamma lookup table is used to adjust the color between different display devices (such as DVI versus VGA). Each of the red, green and blue can be corrected. Each table consists of 256 values.

GAMMA\_B\_LUT\_PTR = $AF:4000

GAMMA\_G\_LUT\_PTR = $AF:4100

GAMMA\_R\_LUT\_PTR = $AF:4200

Gamma can be enabled or disabled.

#### Master Control Register

The Master Control Register (MCR) is used to enable/disable various video mode. The MCR is located at address $AF:0000-1. Bits 8 and 9 are only available to Rev C of the Foenix boards (aka FMX).

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **MCR $AF:0001** | | **MCR ($AF:0000)** | | | | | | | |
| 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Pixel Doubling | Pixel Clock | Disable Vid | Gamma | Sprite | Tilemap | Bitmap | Graph Mode | Text Overlay | Text Mode |

|  |  |  |
| --- | --- | --- |
| **MCR Bit** | **MCR Name** | **Description** |
| 0 | Mstr\_Ctrl\_Text\_Mode\_En | Enable the Text Mode |
| 1 | Mstr\_Ctrl\_Text\_Overlay | Enable the Overlay of the text mode on top of Graphic Mode (the Background Color is ignored) |
| 2 | Mstr\_Ctrl\_Graph\_Mode\_En | Enable the Graphic Mode |
| 3 | Mstr\_Ctrl\_Bitmap\_En | Enable the Bitmap Module in Vicky |
| 4 | Mstr\_Ctrl\_TileMap\_En | Enable the Tile Module in Vicky |
| 5 | Mstr\_Ctrl\_Sprite\_En | Enable the Sprite Module in Vicky |
| 6 | Mstr\_Ctrl\_GAMMA\_En | Enable the GAMMA correction - The Analog and DVI have different color value, the GAMMA is great to correct the difference.  NOTE: This could also be used for fade-in and out. |
| 7 | Mstr\_Ctrl\_Disable\_Vid | This bit disables the Scanning of the Video Memory, hence giving 100% bandwidth to the CPU to access graphic data.  NOTE: In this case the Border color or the background is displayed on the screen (I can't remember) to be advised |
| 8 | Mstr Ctrl\_Pixel\_Clock | 0: 25MHz – 640 x 480 maximum resolution  1: 40Mhz – 800 x 600 maximum resolution |
| 9 | Mstr\_Ctrl\_Pixel\_Doubling | Enable Pixel Doubling (yielding resolutions of 320 x 240 if bit 8 is 0, and 400 x 300 if bit is 1). |

#### Displaying Graphics

C256 has 4 MB of Video RAM available, starting at $B0:0000 and ending at $EF:FFFF.

The order in which images are drawn are:

* Layer 0 - Sprite Layer 0 - Foreground (Closest to the screen)
* Layer 1 - Bitmap Layer 0
* Layer 2 - Sprite Layer 1
* Layer 3 - TileMap Layer 0
* Layer 4 - Sprite Layer 2
* Layer 5 - TileMap Layer 1
* Layer 6 - Sprite Layer 3
* Layer 7 - TileMap Layer 2
* Layer 8 - Sprite Layer 4
* Layer 9 - TileMap Layer 3
* Layer 10 - Sprite Layer 5
* Layer 11 - Bitmap Layer 1
* Layer 12 - Sprite Layer 6 - Background (Farthest from the Screen)

##### Bitmaps

Once the Bitmap bit is set in the MCR, Vicky will read the Bitmap Control Register(s). Rev B can only display a single bitmap. Rev C can display two bitmaps and has two registers.

The Bitmap Control Register is shown below.

|  |  |  |
| --- | --- | --- |
| **Bitmap Control Register ($AF:0140) – Rev B** | | |
| 7 .. 4 | 3 .. 1 | 0 |
| Reserved | LUT | Enable |

|  |  |  |
| --- | --- | --- |
| **Bitmap Control Register ($AF:0100 and $AF:0108) – Rev C** | | |
| 7 .. 4 | 3 .. 1 | 0 |
| Reserved | LUT | Enable |

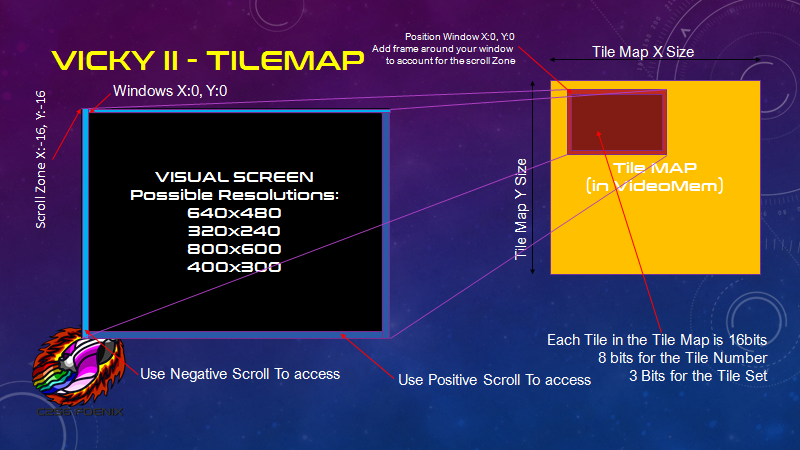
|  |  |  |
| --- | --- | --- |
| **BCR Bit** | **BCR Name** | **Description** |
| 0 | Enabled | Enable the bitmap |
| 1 .. 3 | LUT | Lookup Table Index 0 to 7 |
| 4 .. 7 | Reserved | Reserved |

The address pointer of the bitmap in the Video RAM is located at addresses $AF:0141 to $AF:0143. The address stored must be offset by $B0:0000. As an example, if the bitmap data is stored in at address $B1:4000 in memory, the address pointer must be $01:4000.

The bitmap width is saved in the word $AF:0144 to $AF:0145.

The bitmap height is saved in the word $AF:0146 to $AF:0147.

##### Tiles



Once the Tile bit is set in the MCR, Vicky will retrieve the Tile Control Register at addresses $AF:0100, $AF:0108, $AF:0110 and $AF:0118 to determine if a tileset should be displayed. There can be four tilesets at any given time in the display.

The Tile Control Registers are shown below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Tile Control Register ($AF:0100, $AF:0108, $AF:0110, $AF:0118)** | | | |
| 7 | 6 .. 4 | 3 .. 1 | 0 |
| Tile Striding | Reserved | LUT | Enable |

|  |  |  |
| --- | --- | --- |
| **TCR Bit** | **TCR Name** | **Description** |
| 0 | Enabled | Enable the bitmap |
| 1 .. 3 | LUT | Lookup Table Index 0 to 7 |
| 4 .. 6 | Reserved | Reserved |
| 7 | Tile Striding | 0: sequential, 1: 256 x 256 Tile sheet striding |

Each tile has its own control register, video address pointer, X and Y stride.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Tile 0 | Tile 1 | Tile 2 | Tile 3 |
| Tile Control Register | $AF:0100 | $AF:0108 | $AF:0110 | $AF:0118 |
| Tile Start Address | $AF:0101 .. $AF:0103 | $AF:0109 .. $AF:010B | $AF:0111 .. $AF:0113 | $AF:0119 .. $AF:011B |
| Tile Map X Stride | $AF:0104 .. $AF:0105 | $AF:010C .. $AF:010E | $AF:0114 .. $AF:0115 | $AF:011C .. $AF:011E |
| Tile Map Y Stride | $AF:0106 .. $AF:0107 | $AF:010E .. $AF:010F | $AF:0116 .. $AF:0117 | $AF:011E .. $AF:011F |

Tile maps are stored at addresses $AF:5000, $AF:5800, $AF:6000 and $AF:6800.

##### Sprites

Once the Sprite bit is set in the MCR, Vicky will display sprites in the appropriate layer. There can be 32 sprites displayed for each screen refresh.

The Sprite Control Registers are shown below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Sprite Control Register ($AF:0200 to $AF:02F8, offset by 8 bytes)** | | | |
| 7 | 6 .. 4 | 3 .. 1 | 0 |
| Reserved | Layer | LUT | Enable |

Each sprite has a Control Register, a video memory address, and X and Y locations.

### Beatrix



// $AF:E400..$AF:E4FF // SID (Still to be defined) Not Implemented yet

// $AF:E500..$AF:E5FF // OPL2 - Left Side

// $AF:E600..$AF:E6FF // OPL2 - Right Side

// $AF:E700..$AF:E7FF // OPL2 - Both Side (Write Sequence Only)

// $AF:E800..$AF:E807 // Joystick + AD Channel + SD Controller

// $AF:E820..$AF:E823 // CODEC Register

// $AF:E810..$AF:E81F //SD Card Stat

#### Joystick Ports

The C256 Foenix provides 4 joystick ports, located in front of the machine. The 9-pin connectors are compatible with the standard Atari/Commodore joysticks. Joystick ports are number from right to left, starting near the Reset button.

JOYSTICK0 = $AF:E800 ;(R) Joystick 0 - J7 (Next to Buzzer)

JOYSTICK1 = $AF:E801 ;(R) Joystick 1 - J8

JOYSTICK2 = $AF:E802 ;(R) Joystick 2 - J9

JOYSTICK3 = $AF:E803 ;(R) Joystick 3 - J10 (next to SD Card)

The joysticks do not generate interrupts. Polling ports at a regular interval, say with the SOF interrupt is recommended.

The joystick register has a value at rest of $9F. The bits are set to zero when a switch is closed.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Joystick Register ($AF:E800, $AF: E801, $AF: E802, $AF: E803)** | | | | | | | |
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Button | N/A | N/A | N/A | Left | Right | Down | Up |

**Note: This feature is not implemented in the Foenix IDE yet.**

#### Dip switch Ports

DIPSWITCH = $AF:E804 ;(R) $AFE804...$AFE807

**Note: This feature is not implemented in the Foenix IDE yet.**

#### SD Card

; SD Card CH376S Port

SDCARD\_DATA = $AF:E808 ;(R/W) SDCARD (CH376S) Data PORT\_A (A0 = 0)

SDCARD\_CMD = $AF:E809 ;(R/W) SDCARD (CH376S) CMD/STATUS Port (A0 = 1)

; SD Card Card Presence / Write Protect Status Reg

SDCARD\_STAT = $AF:E810 ;(R) SDCARD (Bit[0] = CD, Bit[1] = WP)

; Audio WM8776 CODEC Control Interface (Write Only)

CODEC\_DATA\_LO = $AF:E820 ;(W) LSB of Add/Data Reg to Control CODEC See WM8776 Spec

CODEC\_DATA\_HI = $AF:E821 ;(W) MSB od Add/Data Reg to Control CODEC See WM8776 Spec

CODEC\_WR\_CTRL = $AF:E822 ;(W) Bit[0] = 1 -> Start Writing the CODEC Control Register

**Note: This feature is not implemented in the Foenix IDE yet.**

## Communicating with the Machine over the USB Port

The machine has a USB port that allows for easy transfer of data from the C256 IDE directly to the machine.

When sending commands to the machine, an 8-byte array is the minimum length.

* Byte 0: Header = $55
* Byte 1: Command
* Byte 2: Destination Address (H)
* Byte 3: Destination Address (M)
* Byte 4: Destination Address (L)
* Byte 5: Destination Size (H)
* Byte 6: Destination Size (L)
* Byte 7: Checksum – XOR all the previous bytes

The Destination Address and Destination Size only needs to be specified if writing to memory.

### Read from Memory Command ($00)

### Write to Memory Command ($01)

### Program Flash Command ($10)

The command "Program Flash", you need to supply the Pointer in RAM of where the Flash image will be. The overhead for this one is even longer, each write byte in Flash takes about 20us. So 512K x 20us = 10Sec. So, in theory, you should have an answer to that command 10 second after sending it, indicating that it is now complete.

### Erase Flash Command ($11)

Now, the Command "Erase Flash" doesn't have any specific parameters, but the command needs to follow the same protocol as "Stop CPU" or "Start CPU". The overhead to receive an answer from that command is around 100ms. So, make sure the serial interface can wait that long.

### Set Debug Mode Command ($80)

### Exit Debug Mode Command ($81)

### Get Revision ($FE)

Use this to receive the Debug core version, if you want to make the difference between RevB2 and other revisions.

Value returned:

* $00 - RevB2
* $01 - Everything at RevC4A and after (or RevC4 with more features)

# Sample Code

Use the VDMA in linear mode to transfer data.

## Linear Mode VDMA Transfer

SETUP\_VDMA\_FOR\_TESTING\_1D

setas

LDA #$01 ; Start Transfer

STA @lVDMA\_CONTROL\_REG

LDA #$FE

STA @lVDMA\_SIZE\_L

LDA #$9F

STA @lVDMA\_SIZE\_M

LDA #$00

STA @lVDMA\_SIZE\_H

LDA #$64

STA @lVDMA\_DST\_ADDY\_L

LDA #$84

STA @lVDMA\_DST\_ADDY\_M

LDA #$03

STA @lVDMA\_DST\_ADDY\_H

LDA #$55

STA @lVDMA\_BYTE\_2\_WRITE

LDA #$85 ; Start Transfer

STA @lVDMA\_CONTROL\_REG

LDA @lVDMA\_STATUS\_REG

RTS

## Block Mode VDMA Transfer

SETUP\_VDMA\_FOR\_TESTING\_2D

setas

VDMA\_WAIT\_TF

; Wait for the Previous Transfer to be Finished

LDA @lVDMA\_STATUS\_REG

AND #VDMA\_STAT\_VDMA\_IPS

CMP #VDMA\_STAT\_VDMA\_IPS

BEQ VDMA\_WAIT\_TF

LDA #$01 ; Start Transfer

STA @lVDMA\_CONTROL\_REG

LDA #200

STA @lVDMA\_X\_SIZE\_L

LDA #00

STA @lVDMA\_X\_SIZE\_H

LDA #64

STA @lVDMA\_Y\_SIZE\_L

LDA #00

STA @lVDMA\_Y\_SIZE\_H

LDA #$60

STA @lVDMA\_DST\_ADDY\_L

LDA #$90

STA @lVDMA\_DST\_ADDY\_M

LDA #$01

STA @lVDMA\_DST\_ADDY\_H

LDA #$80

STA @lVDMA\_DST\_STRIDE\_L

LDA #$02

STA @lVDMA\_DST\_STRIDE\_H

LDA #$F9

STA @lVDMA\_BYTE\_2\_WRITE

LDA #$87 ; Start Transfer

STA @lVDMA\_CONTROL\_REG

LDA @lVDMA\_STATUS\_REG

RTS

## Clear Screen with VDMA

Code Example of Bitmap ClearScreen with the 2D Mode that happens to work better than the 1D Mode:

CLEAR\_BITMAP

setas

CLR\_SCREEN\_CHECK\_NO\_ACTIVE\_DMA

; Wait for the Previous Transfer to be Finished

LDA @lVDMA\_STATUS\_REG

AND #VDMA\_STAT\_VDMA\_IPS

CMP #VDMA\_STAT\_VDMA\_IPS

BEQ CLR\_SCREEN\_CHECK\_NO\_ACTIVE\_DMA

LDA #$01 ; Enable VDMA Block

STA @lVDMA\_CONTROL\_REG

LDA #$80

STA @lVDMA\_X\_SIZE\_L

LDA #$02

STA @lVDMA\_X\_SIZE\_H

LDA #$E0

STA @lVDMA\_Y\_SIZE\_L

LDA #$01

STA @lVDMA\_Y\_SIZE\_H

LDA #$00

STA @lVDMA\_DST\_ADDY\_L

LDA #$00

STA @lVDMA\_DST\_ADDY\_M

LDA #$00

STA @lVDMA\_DST\_ADDY\_H

LDA #$80

STA @lVDMA\_DST\_STRIDE\_L

LDA #$02

STA @lVDMA\_DST\_STRIDE\_H

LDA #$00

STA @lVDMA\_BYTE\_2\_WRITE

LDA #$87 ; Start Transfer

STA @lVDMA\_CONTROL\_REG

LDA @lVDMA\_STATUS\_REG

RTS

## Start of Line Interrupt

Setting up of the SOL:

LDA #$F0 ; <- Video Line Value

STA @lVKY\_LINE0\_CMP\_VALUE\_LO

LDA #$01 ; Enable Line Interrupt

STA @lVKY\_LINE\_IRQ\_CTRL\_REG

Servicing the interrupt:

SOL\_INTERRUPT setas

LDA @lINT\_PENDING\_REG0

AND #FNX0\_INT01\_SOL

STA @lINT\_PENDING\_REG0

; Your Code here

LDA #$00

STA @lBACKGROUND\_COLOR\_B

RTL

Interrupt Handler

IRQ\_HANDLER

setas ; Set 8bits

.

.

.

SERVICE\_NEXT\_IRQ1

; Start of Frame Interrupt

LDA @lINT\_PENDING\_REG0

AND #FNX0\_INT01\_SOL

CMP #FNX0\_INT01\_SOL

BNE SERVICE\_NEXT\_IRQ6

; Start of Frame Interrupt

JSL SOL\_INTERRUPT

BRA EXIT\_IRQ\_HANDLE

.

.

.

SERVICE\_NEXT\_IRQ6

.

.

.

EXIT\_IRQ\_HANDLE

RTI