Pixie Virtual Machine

# Overview

The PixieVM CPU is a 16-bit Big Endian CPU with 4 16-bit general purpose registers A, B, C, D, one 16-bit index register X, a 16-bit stack pointer SP, a 16-bit instruction pointer IP and a 16-bit flags register FLAGS. FLAGS holds various CPU state flags ie. negative, overflow, break, interrupt disable, zero and carry in the following format:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| - | - | - | - | - | - | - | - | N | V | - | - | B | I | Z | C |

Each general purpose register can be referred to by it's high and low byte:

|  |  |  |  |
| --- | --- | --- | --- |
| AX | BX | CX | DX |
| |  |  | | --- | --- | | AH | AL | | |  |  | | --- | --- | | BH | BL | | |  |  | | --- | --- | | CH | CL | | |  |  | | --- | --- | | DH | DL | |

# Addressing Modes

The PixieVM CPU has a very orthogonal instruction set. The table below describes the various addressing modes supported with examples of their usage.

|  |  |  |
| --- | --- | --- |
| Mode | Description | Example |
| RR8 | 8-bit source and destination register | xor ch, ch |
| RR16 | 16-bit source and destination register | xor d, d |
| RM8 | 8-bit destination register, memory source | mov al, [d+x] |
| RM16 | 16-bit destination register, memory source | mov a, [b+x] |
| RA8 | 8-bit destination register, absolute source | mov bl, [$c000] |
| RA16 | 16-bit destination register, absolute source | mov a, [$ffe0] |
| RI8 | 8-bit destination register, 8-bit immediate source | mov dh, $c0 |
| RI16 | 16-bit destination register, 16-bit immediate source | mov d, $8000 |
| MR8 | memory destination, 8-bit register source | mov [d+x], al |
| MR16 | memory destination, 16-bit register source | mov [a+x], b |
| M8I8 | 8-bit memory destination, 8-bit immediate source | mov BYTE [a+x], $ff |
| M16I8 | 16-bit memory destination, 8-bit immediate source | mov WORD [a+x], $ff |
| MI16 | 16-bit memory destination, 16-bit immediate source | mov [b+x], $c000 |
| AR8 | 16-bit absolute destination, 8-bit register source | mov [$ce00], al |
| AR16 | 16-bit absolute destination, 16-bit register source | mov [$cd00], b |
| A8I8 | 8-bit absolute destination, 8-bit immediate source | mov BYTE [$e000], $1 |
| A16I8 | 16-bit absolute destination, 8-bit immediate source | mov WORD [$e000], $1 |
| AI16 | 16-bit absolute destination, 16-bit immediate source | mov [$0800], $ffff |
| R8 | 8-bit register | inc al |
| R16 | 16-bit register | inc b |
| M8 | 8-bit memory | dec BYTE [a+x] |
| M16 | 16-bit memory | dec WORD [a+x] |
| A8 | 8-bit absolute | dec BYTE [$fe00] |
| A16 | 16-bit absolute | inc WORD [$cd00] |
| IMPLIED | Implied | sei |
| I8 | Immediate 8-bit | push $c0 |
| I16 | Immediate 16-bit | jmp $8000 |

# Instructions

The CPU instructions are grouped into 7 different categories based on how they are used. Each group defines a set of addressing modes supported by that instruction.

|  |  |
| --- | --- |
| Address Group | Addressing modes |
| I | RR8, RR16, RM8, RM16, RA8, RA16, RI8,  RI16, MR8, MR16, M8I8, M16I8, MI16, AR8, AR16, A8I8, A16I8, AI16 |
| II | R8, R16, M8, M16, A8, A16 |
| III | IMPLIED |
| IV | R16, M16, A16, I16 |
| V | I8 |
| VI | R8, R16, M8, M16, A8, A16 |
| VII | R8, R16, M8, M16, A8, A16, I8, I16 |

The following table lists each CPU instruction mnemonic followed by what addressing group it belongs to and a brief description.

|  |  |  |
| --- | --- | --- |
| Instruction Mnemonic | Address Group | Description |
| ADC | I | Add with carry |
| AND | I | Bitwise AND |
| BIT | I | Test bits |
| BRK | III | Break execution |
| CALL | IV | Call subroutine |
| CLC | III | Clear carry flag |
| CLI | III | Clear interrupt flag |
| CMP | I | Compare |
| DEC | II | Decrement integer |
| DEX | III | Decrement X register |
| INC | II | Increment integer |
| INX | III | Increment X register |
| IRET | III | Return from interrupt |
| JCC | V | Jump on carry clear |
| JCS | V | Jump on carry set |
| JMI | V | Jump on negative flag set |
| JMP | IV | Unconditional jump |
| JNZ | V | Jump on result not zero |
| JPL | V | Jump on negative flag clear |
| JVC | V | Jump on overflow clear |
| JVS | V | Jump on overflow set |
| JZ | V | Jump on zero flag set |
| MOV | I | Move data |
| NOP | III | No operation |
| OR | I | Bitwise OR |
| POP | VI | Pop from stack |
| POPA | III | Pop from stack into .A |
| POPF | III | Pop from stack into FLAGS |
| PUSH | VII | Push onto stack |
| PUSHA | III | Push .A onto stack |
| PUSHF | III | Push FLAGS onto stack |
| RET | III | Return from subroutine call |
| ROL | II | Rotate bits left |
| ROR | II | Rotate bits right |
| SBB | I | Subtract with borrow |
| SEC | III | Set carry flag |
| SEI | III | Set interrupt-disable flag |
| SHL | II | Shift bits left |
| SHR | II | Shift bits right |
| XOR | I | Bitwise exclusive-OR |