ECE 498 – Linux Assembly Language Lecture 7

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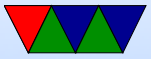
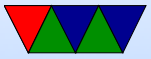
8-bit 6502 Review

- 8-bit processor
- 3 8-bit registers: A (Accumulator), X, Y (index)
- 16-bit PC
- 8-bit status flag (P): NV-BDIZC
  Negative, oVerflow, Break, Decimal, Interrupt, Zero, Carry
- 8 bit stack pointer (page 1, $0100-$01ff), grows down

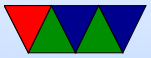


- 16-bit data bus (64k) little-endian
- Fast access to Page 0, $0000-$00FF
- Instructions 1-3 bytes
- Chuck Peddle (Maine '60) co-designer

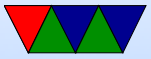


Addressing Modes

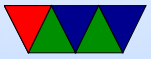
- accumulator: `ASL` assumes accumulator
- implied: `DEX` implies X
- immediate: `LDA #$12` immediate byte
- absolute: `LDA $1234` load from address
- zeropage: `LDA $12` loads from zero page
- zeropage,X: `LDA $12,X`



- zeropage,Y: `OPC $12,Y`
- absolute, X: `LDA $1234,X` load from address+X
- absolute, Y: `LDA $1234,Y` load from address+Y
- indirect: `JMP ($1234)` jump to address found at $1235/$1234
- indirect, Y-index `LDA ($12),Y` get address from ZP $13/$12, add Y, load
- X-indexed: indirect: `LDA ($12,X)` *(ZP+X) (wraps)

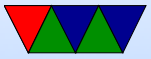


- jump relative `OPC $BB` target is PC + BB



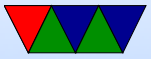
Instruction Set

- ADC – add to A w cary
- AND – and mem with accumulator
- ASL – arithmetic shift left A or mem (by one)
- BCC, BCS – branch on carry clear/set
- BEQ, BNE – branch on equal (Z set)
- BIT – bit test mem w A (result in Z). Also set N and V

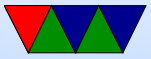


to mem bits 7 and 6

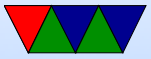
- BMI,BPL – branch minus (N set)
- BRK – sw interrupt
- BVC, BVS – branch overflow (V set)
- CLC, CLD, CLI, CLV – clear carry, decimal, interrupt, overflow
- CMP – compare (mem with accumulator)
- CPX, CPY – compare mem with X or Y



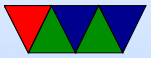
- DEC, DEX, DEY – decrement memory, X, Y
- EOR – exclusive or mem (with accumulator)
- INC, INX, INY – increment memory, X, Y
- JMP – jump
- JSR – jump subroutine
- LDA, LDX, LDY – load A, X, Y from mem
- LSR – logical shift right by one



- NOP – no operation
- ORA – or mem with accumulator
- PHA, PLA – push/pop accumulator
- PHP, PLP – push/pop status reg
- ROL, ROR – rotate mem or A left/right
- RTI – return from interrupt
- RTS – return from subroutine

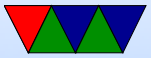


- SBC – subtract memory from A w borrow
- SEC, SED, SEI – set carry, decimal, interrupt
- STA, STX, STY – store A, X, Y to mem
- TAX, TAY – transfer accumulator to X, Y
- TSX, TXS – transfer stack pointer to X
- TXA, TYA – transfer X, Y to accumulator

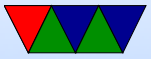


Apple IIe Enhanced

- Apple II released in 1977
- Apple IIe Platinum released in 1987
- 1MHz 65C02 Processor, 128kB RAM
  (guess about C stands for? How 128kB?)
- 280x192, 6-color graphics (IIe can do DoubleHiRes)
- Press M at boot for menu

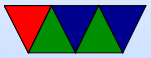


- Power: 18 - 20W
- Original machine discrete 7400 logic



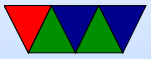
Cross-Assembler

- Use ca65 assembler that comes with cc65 compiler



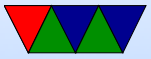
Simulator

- Use linapple simulator



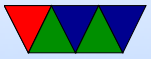
Hello World

putstring code demo



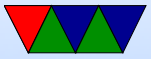
6502 Code Density

- So many 1-byte instructions! Small address! Why isn't code small?
- 8-bits really too small.
- Awkward emulating 16-bit. 16-bit increment



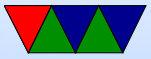
65c816

- 24-bit addressing (16MB)
- 16-bit stack pointer
- boot in 6502 mode, switch to 16-bit
- X bit: X and Y 16-bit
- M bit: A and Mem 16-bit
- D register – allows setting Zero (Direct) page anywhere



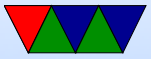
in first 64kb

- Bank register – set which 64kB (of the 16MB) in use at time

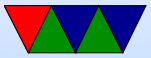


65c816 instructions (some on 65c02 as well)

- xce –start 16-bit mode (X bit replaces B) exchange carry and emulation
- xba – exchange top and bottom of A
- mvp/mnv block move instructions (X start, Y dest, A bytes to move) pos/neg
- txy,tyx – move between x and y
- bra – branch always



- inc,dec A
- stz – store zero
- tsb, trb – test and set bit, test and reset bit
- stack relative address mode
- lda ($1234) – load indirect w/o index
- lda $123456 – load with bank
- phx,plx,phy,ply – push/pop X and Y



Discuss the Project