Nintendo Gameboy Architecture and Design

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Gameboy: Overview

- History
- CPU
  - Z80
  - 8080
  - Hybrid
- Memory
  - Cartridges
    - Reading
    - Structure

Gameboy: History

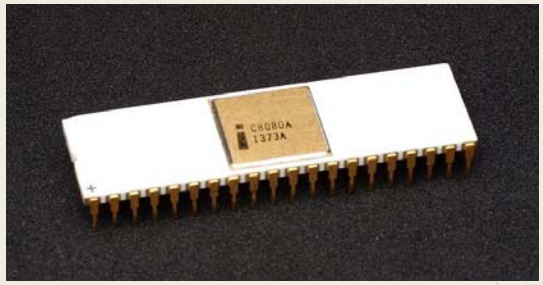
- 8-bit handheld device
  - Successor of Game and Watch series (1980)
  - Older hardware / mobility focus
- Nintendo
  - Released April 21, 1989 (JPN)
  - Gunpei Yokoi + Nintendo R&D1
- Foundation for the Gameboy handheld series
- Helped set precedents for mobile devices

Gameboy: Technical Details

- CPU: 8-bit Hybrid Zilog Z80 and Intel 8080 based processor
  - Result: Sharp LR35902
- Clock Speed: 4.19 MHz
- Working RAM: 8KB
- Video RAM: 8KB
- Resolution: 160x144 (2.6” screen)
- Colors: 4 gray shades
- Sound: 4 channels with stereo sound
- Power: DC 6V, 0.7W

Intel 8080: History

- “The first truly usable microprocessor”
  - Huge industry impact
- General Purpose Microprocessor
- Main Design: Intel Engineers:
  - Federico Faggin
  - Masatoshi Shima
- Released April 1974

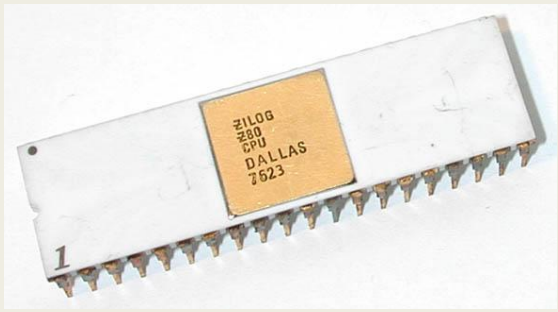


Intel 8080: Technical Details

- Opcode usage
- 16 bit address bus
- 8 bit data bus
- 64KB of byte-addressable memory
- 2MHz clock speed
- Registers:
  - 8 bit accumulator
  - 8 bit status register
  - Six 8 bit general purpose registers
  - 16 bit stack pointer
  - 16 bit program counter

Zilog Z80: History

- Origin of Zilog
- Superset of the 8080
- 8080 similarities
  - Design team - Intel 8080 Engineers
    - Ralph Ungermann
    - Federico Faggin
  - Binary Compatibility with 8080
  - Opcode usage
- General Purpose Microprocessor
- Released July 1976



Zilog Z80: Technical Details

- Instruction extender: 0xCB
- Interrupt system
- Special IX + IY registers
- 2.5 MHz clock speed
- Based off of 8080 - similar capabilities
  - Similar registers, stack pointer, program counter, bus sizes

Sharp LR35902: Comparisons

- Custom hybrid of the Z80 + 8080
  - Application specific
- ISA + Syntax: Z80
- Instruction extender: Z80
  - Bit-manipulation instructions
- Register set: 8080
  - No IX, IY (no index + base addressing)
- Faster clock speed: 4 MHz
- Single address space: no IO addresses
- 8080 - 1974, Z80 - 1976, Gameboy - 1989
- Design of hardware for the device

Memory

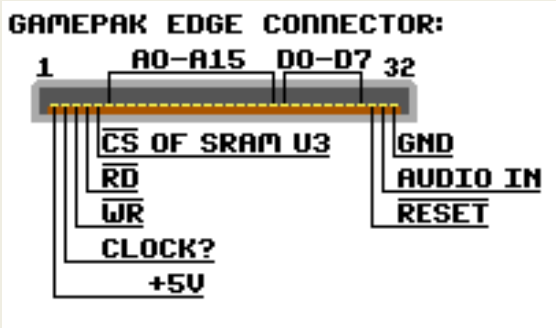
- 16 bit address bus =
  64kB address space
- GamePak: 0000-7FFF and A000-BFFF
- “Character RAM” = Video RAM
  - Split into 32x32 tiles, 8x8 pixels each
  - Total of 256x256 pixels, with 160x144pixels displayed at a time

GameBoy Memory Areas

$FFFF	Interrupt Enable Flag
$FF80-$FFFE	Zero Page - 127 bytes
$FF00-$FF7F	Hardware I/O Registers
$FEA0-$FEFF	Unusable Memory
$FE00-$FE9F	OAM - Object Attribute Memory
$E000-$FDFF	Echo RAM - Reserved, Do Not Use
$D000-$DFFF	Internal RAM - Bank 1-7 (switchable - CGB only)
$C000-$CFFF	Internal RAM - Bank 0 (fixed)
$A000-$BFFF	Cartridge RAM (If Available)
$9C00-$9FFF	BG Map Data 2
$9800-$9BFF	BG Map Data 1
$8000-$97FF	Character RAM
$4000-$7FFF	Cartridge ROM - Switchable Banks 1-xx
$0150-$3FFF	Cartridge ROM - Bank 0 (fixed)
$0100-$014F	Cartridge Header Area
$0000-$00FF	Restart and Interrupt Vectors

The GamePak

- 32-pin edge connector
- ROM split into 16kB blocks
  - Memory map of the system supports 1 permanent bank and 1 switchable bank
  - Swapped using Memory Bank Controllers (MBC)
- 8kB of RAM
  - Battery sometimes required



Memory Bank Controllers

- Manages the bank swapping of the GamePak
- Five versions
  - MBC1-MBC5
  - Expands ROM capacity to 2MB-8MB
- Requires explicit activation

Conclusion

- Hybrid CPU
  - Intel 8080
  - Zilog Z80
- Emphasis on older hardware
  - 10+ year old CPU
- Memory
  - 64kB of total addressing space
  - 16kB swappable banks on the cartridge
- Innovation

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