How do you write an emulator anyway ?

Whoami

- Anisse Astier
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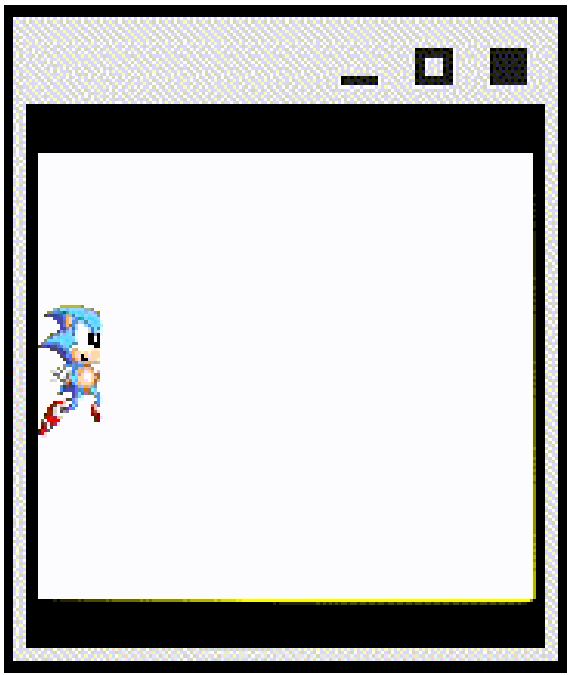
- https://anisse.astier.eu
- Writing gears, a Game Gear emulator
- Not an emulation expert
- Presented Z80 : the last secrets in 2022 and WASM101 yesterday



Why this presentation

- Will :
  - Give pointers
  - Help you start
- Not :
  - Exhaustive
  - Why
- Focus on simpler (8bits) platforms

What is an emulator ?

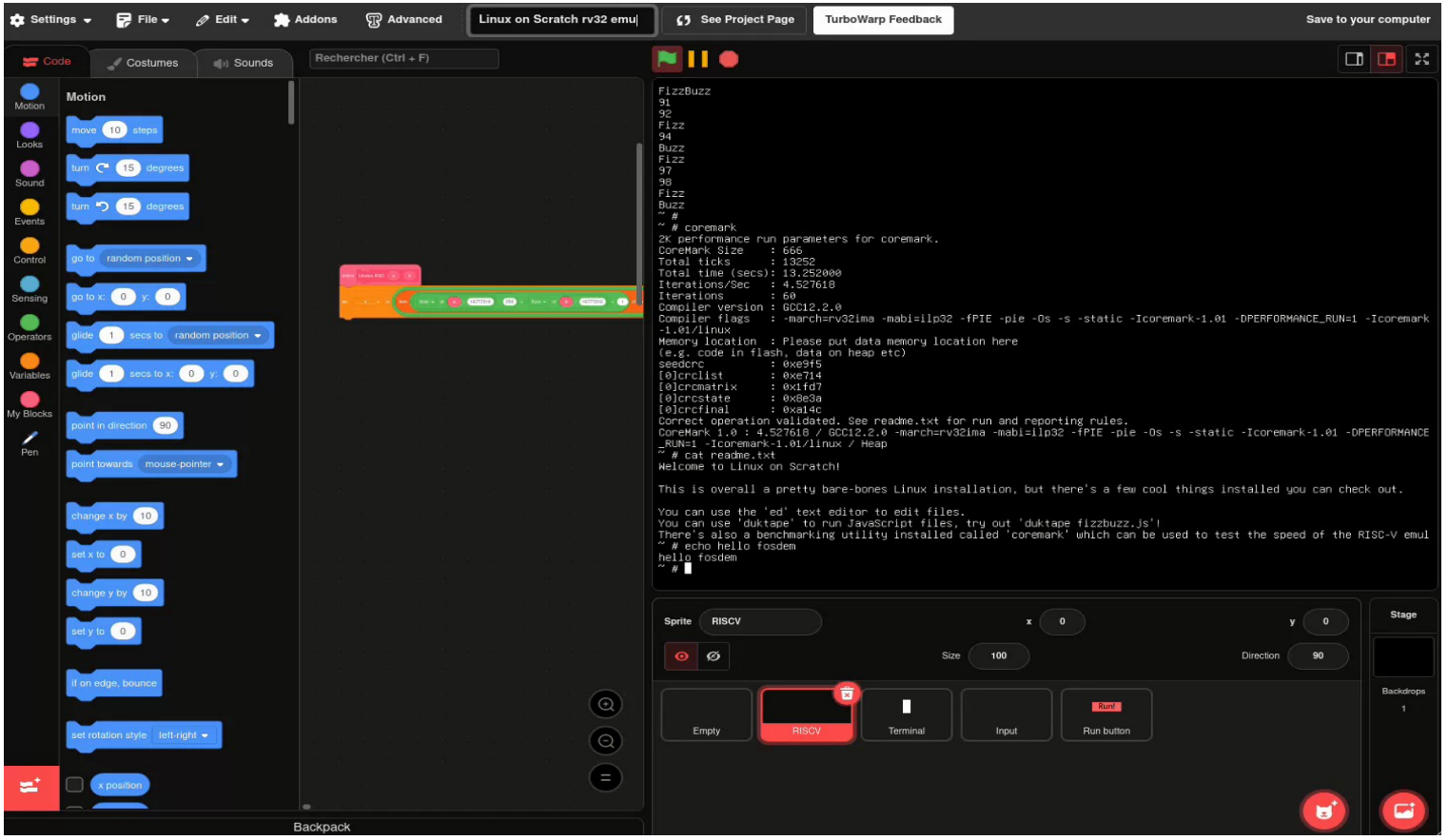
- A software program
- To run software from another computer

What is an emulator ?

What is an emulator ?

- Spectrum of emulation and accuracy
  - One software
  - All software
  - Clock accurate

A crazy example

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STARTING
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Where to start ?

- Pick a target
- Pick a host platform
- Make sure you have time

Where to start ?

- Start simple: one CPU instruction
  - Debug code, minimal disassembler : can you recognize the instruction ?
  - Execution : run it, model CPU state and change it
  - Test : verify state change
- Learn CPU concepts as you go

Interesting CPU concepts

- State: registers
- Instruction
  - Assembly
  - Encoding
- Interrupts
- Memory access


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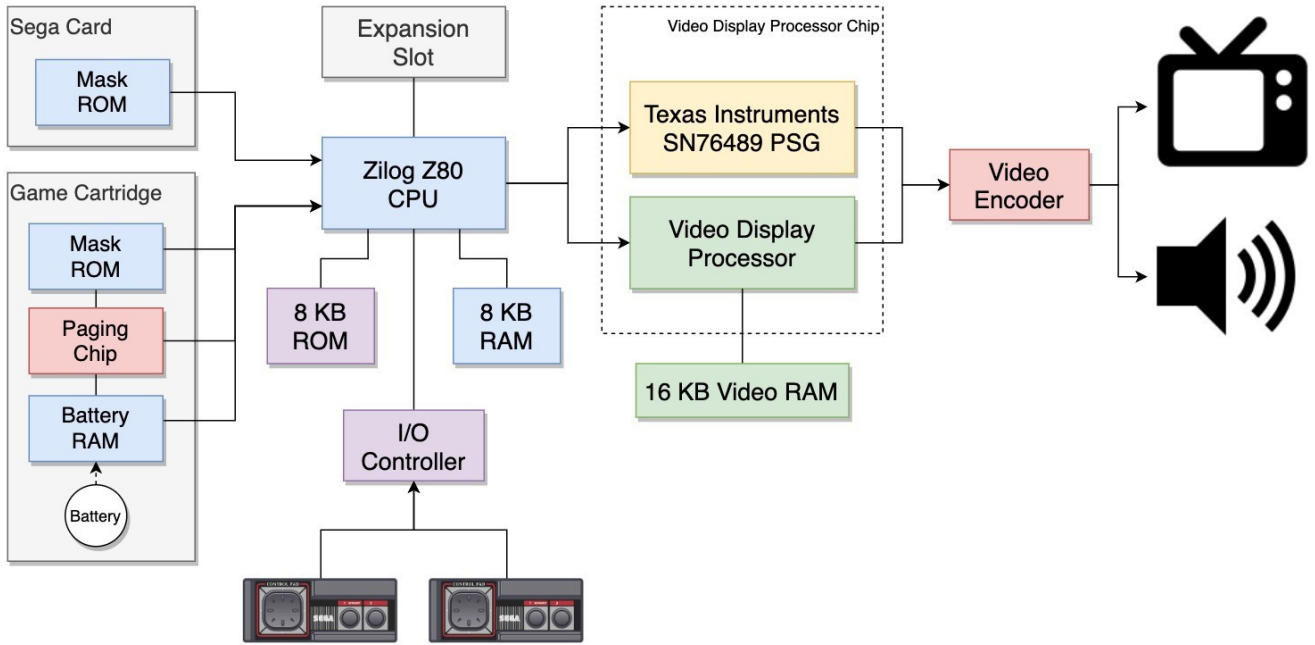
STRUCTURE

Emulator structure

- Examples of 8-bit consoles
  - NES, SMS, GB, Atari 2600, Game Gear
- Various parts :
  - CPU
  - Display
  - Sound
  - Memory
  - ROM mapping
  - Input

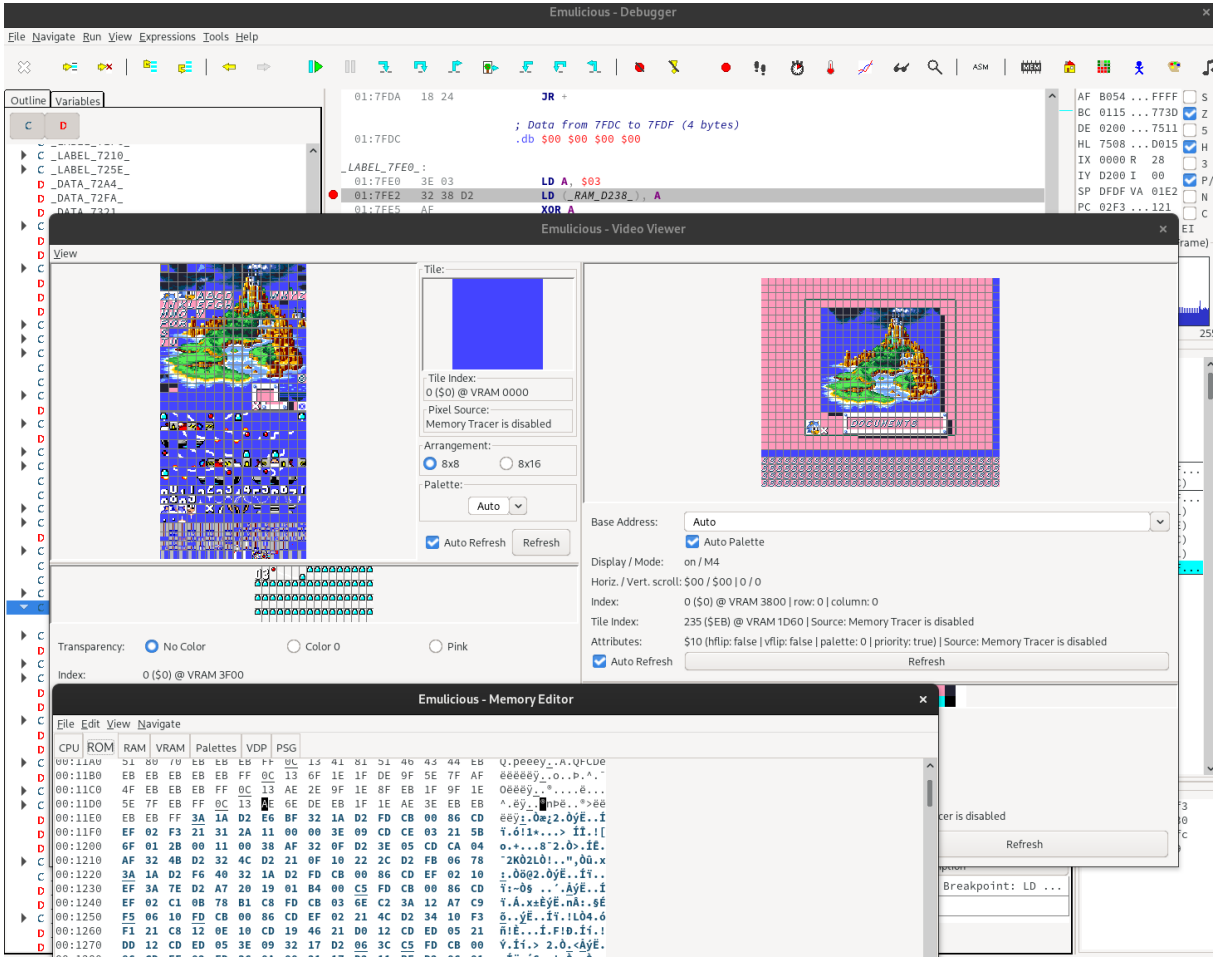


Structure: tricks

- Devices : simple code boundary
- CPU : you are allowed to optimize a bit in advance (no allocation, jump tables)
- Vertical slice : common advice
  - Do what works for you

Structure: tricks

- You will need a debugger
  - Build tooling early
  - Or use already existing

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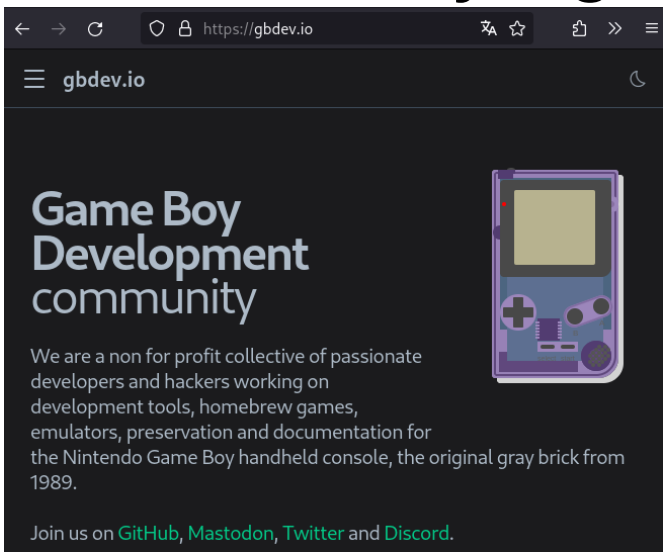
DOCUMENTS

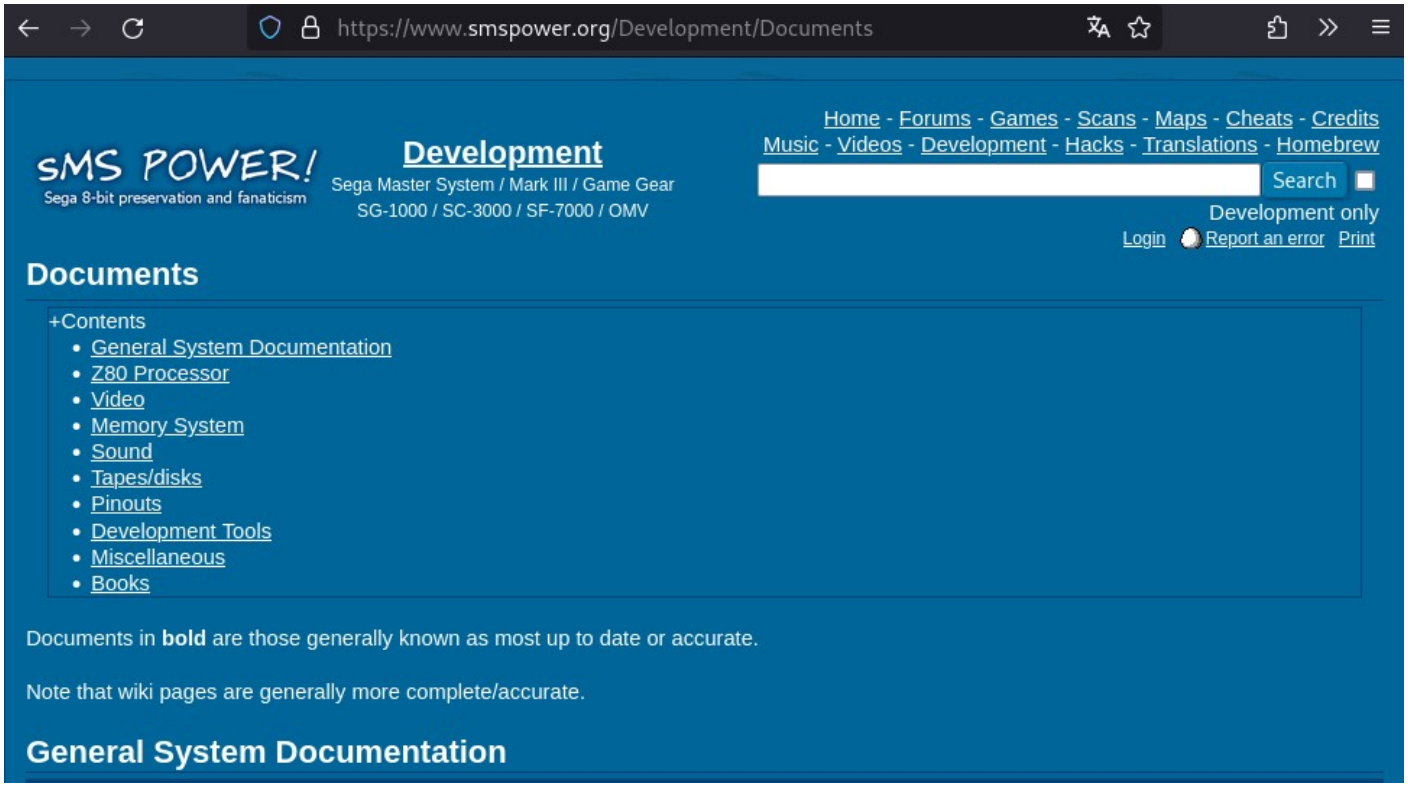
Finding documentation

- Game boy : gbdev.io, Gekkio’s CTR



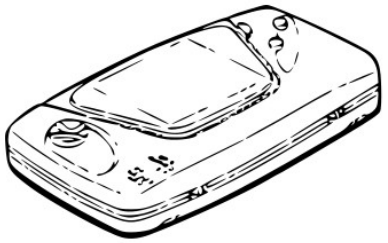
Finding documentation

- SMS
- Game Gear



Finding documentation

Hardware Reference Manual
for the
SEGA Game Gear Console



zilog
Embedded in Life
An IXYS Company

Z80 Microprocessors

Z80 CPU

User Manual

UM008011-0816

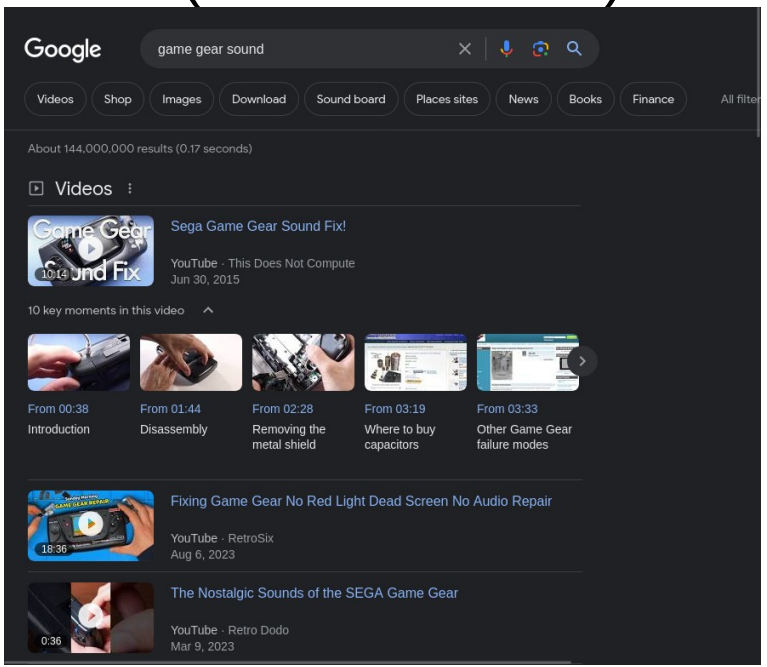
The Undocumented Z80 Documented

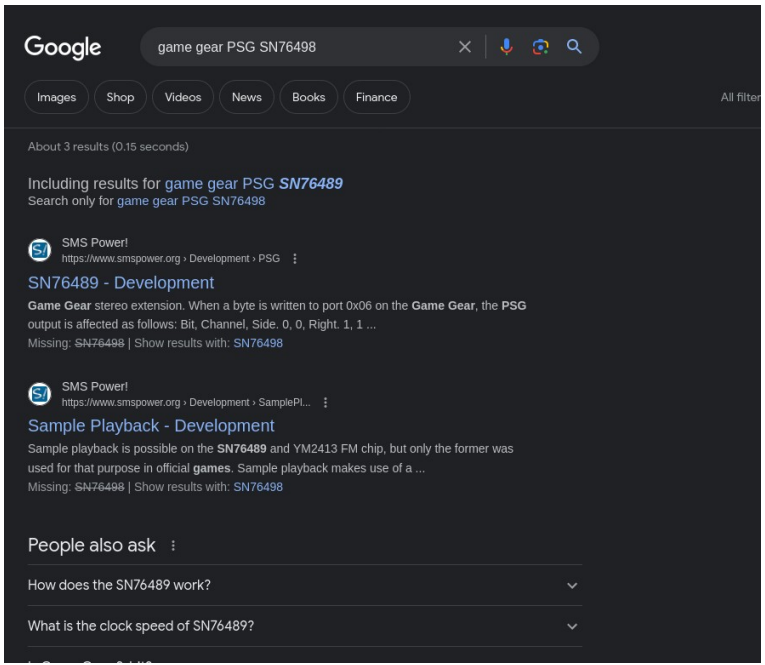
Sean Young

Version 0.91, 18th September, 2005

Finding documentation

- Do web searches with technical terms. Ex : search for <sound chip name> (SN76498/PSG) instead of <console sound>



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PRACTICAL

Device I/O

- Used to be almost as simple as writing to a memory address
- Dedicated instructions

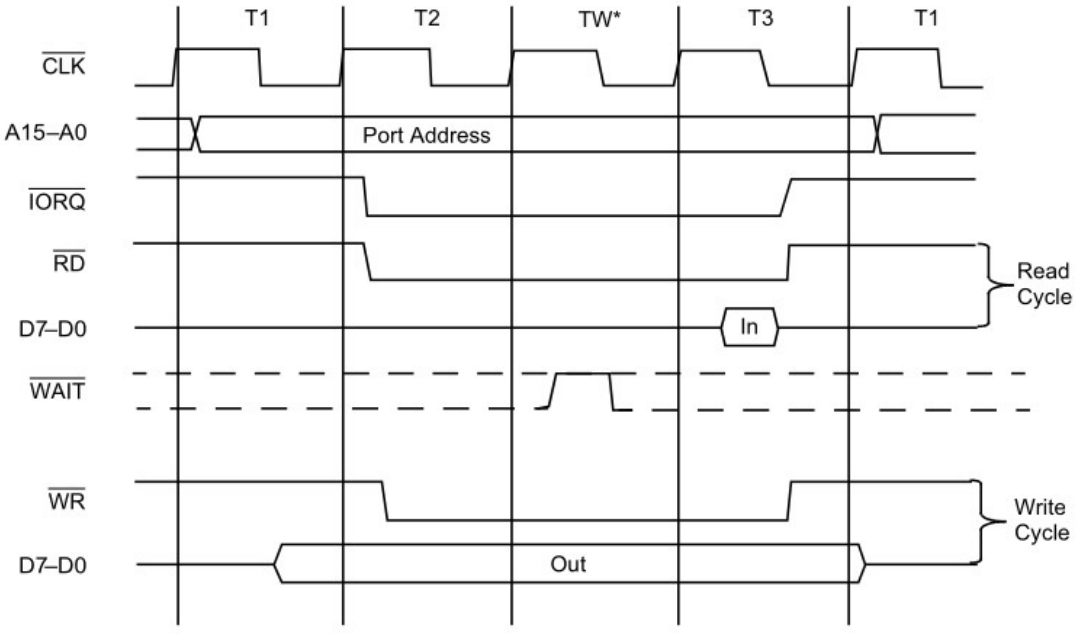


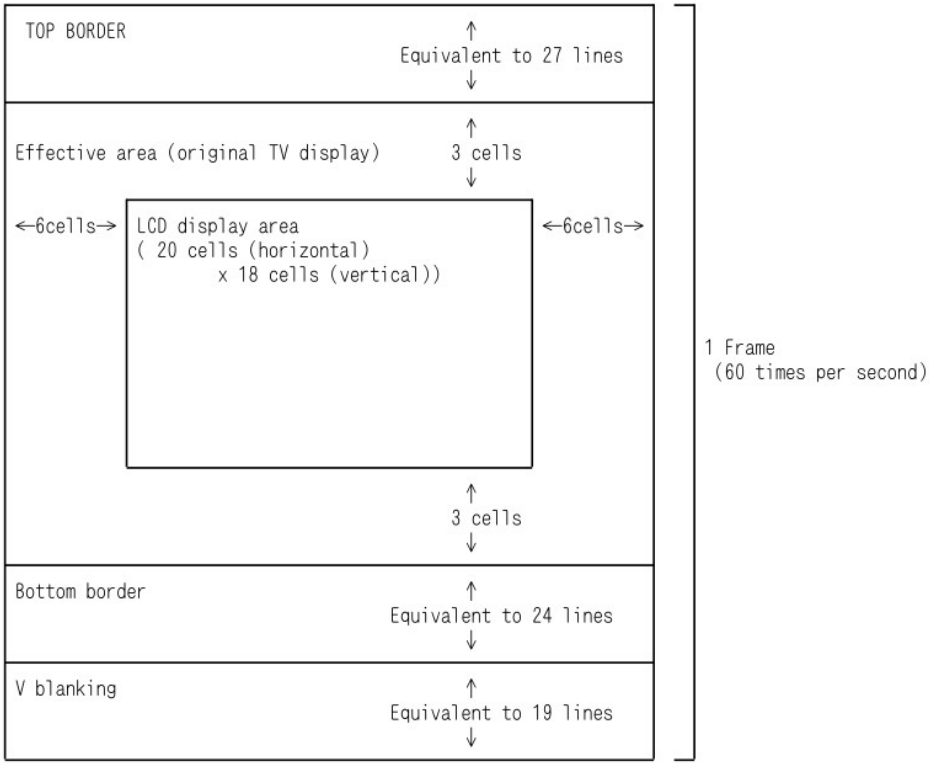
Figure 7. Input or Output Cycles

Displaying something and making sound

- Understand your host platform first
- Hello world of video
  - Display a pixel buffer, change it 60 times a second
- Hello world of sound
  - Play a sine or square wave
- Nothing emulator specific

Graphics emulation

- Needs hardware understanding
- VDP example
  - VRAM/Regs I/O
  - Two planes : BG and sprites
  - BG is on torus, scrollable

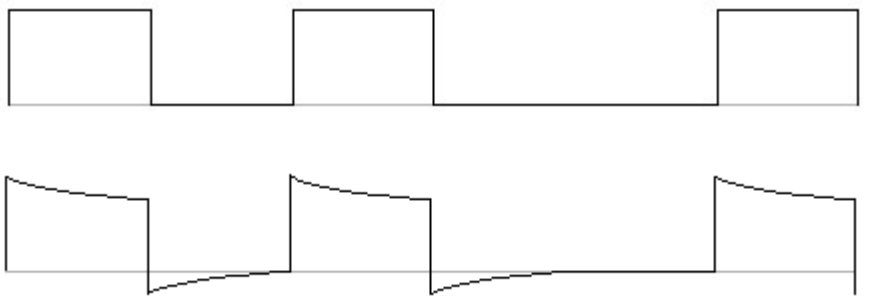


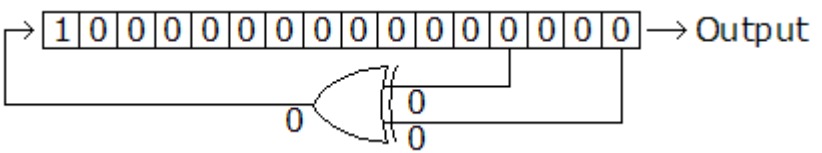
Graphics emulation

- VDP example (cont)
  - Sprites are limited
  - Color encoding
  - Sprite pixel encoding
- Sync strategy: line

Sound emulation

- Needs hardware understanding
- PSG example
  - Regs I/O
  - Channels
  - Tones
    - Counter
  - Noise
    - Random/LFSR
    - Periodic





Sound emulation

- Start simple
  - Square wave
- Example : counter, not frequency

- Example : playing samples
- Sync strategy: cycles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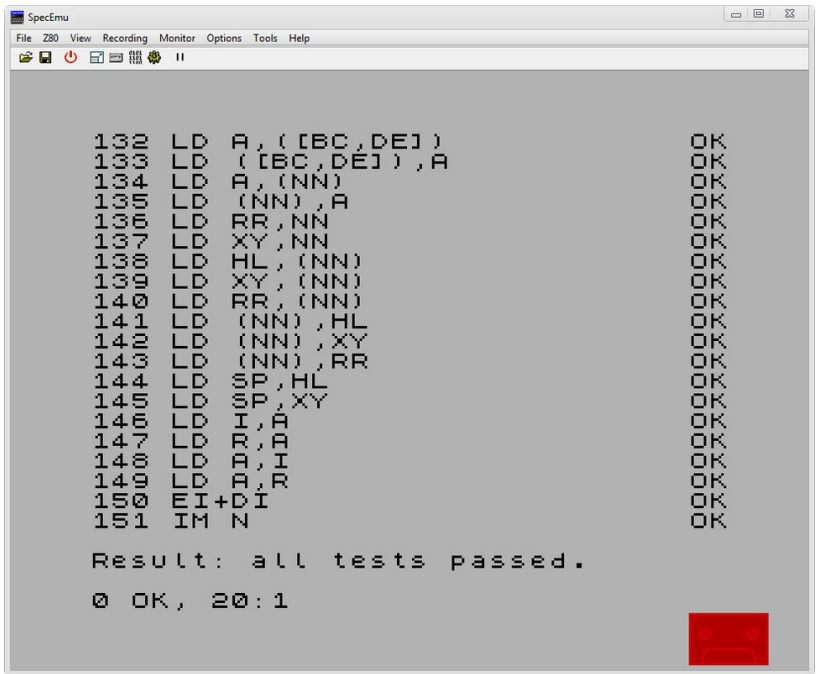
TESTING

Emulator testing: CPU

- Unit test components using existing test suites.
- Examples for Z80
  - Zexall
  - Z80test
  - Fuse test suite

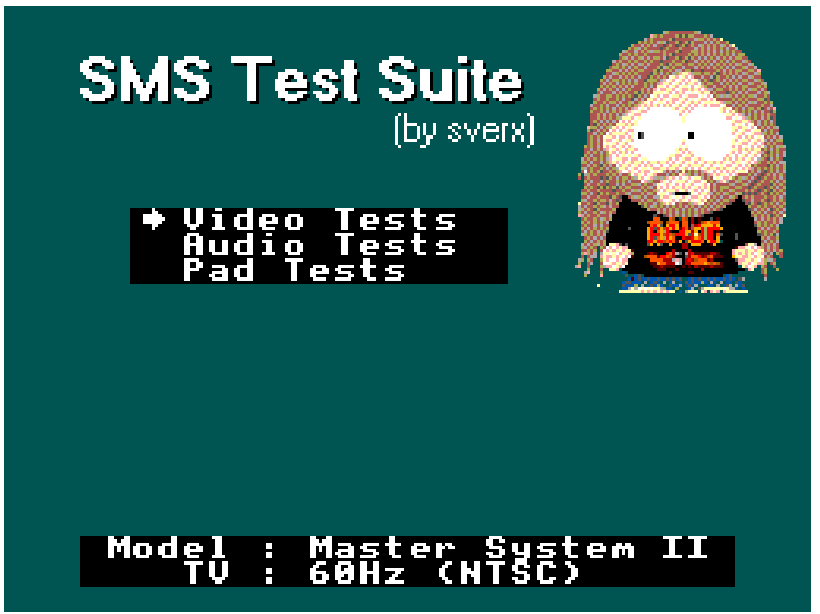


Emulator testing: audio

- Sound:
  - Listen to music, needs a good ear
  - FFTs
  - Can you hear samples (SEGA sound)

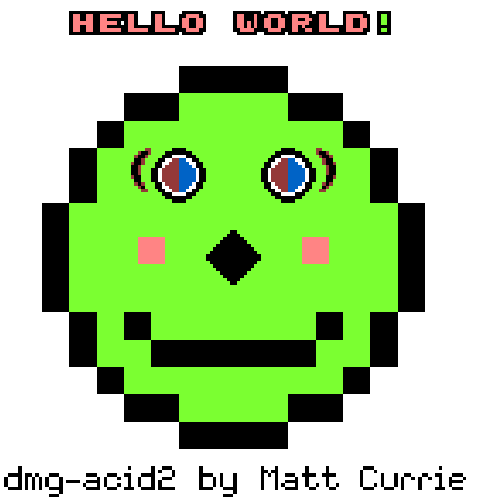
Emulator testing: roms and display

- GG test suite, SMS test suite, inspired by 240p



Emulator testing: roms and display

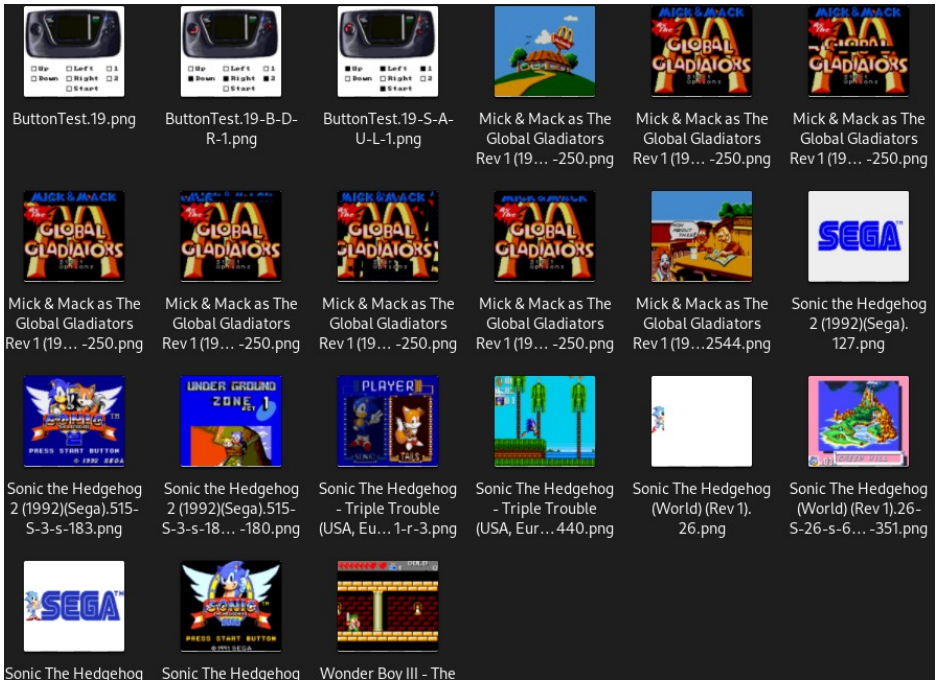
- Game boy examples:
  - dmg-acid2 ppu test
  - Blargg’s gb tests
  - Mooneye test suite



Emulator testing: frame generation

- Integration testing: automate frame generation
  - Everything is deterministic
- Compare with other (good) emulators
- Use real hardware
  - Tip: use flash carts
- Try lots of software/games/roms

Emulator testing: frame generation

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SUMMARY

Summary

- Pick platforms
- Start small
- Read lots of documentation
- Test
- Write and talk about it

Thank you ! Questions ?

Links

- My emulator, gears: https://github.com/anisse/gears
- gears in the browser: https://anisse.github.io/gears
- Romhack to generate level screens: https://gist.github.com/anisse/c6e4101236708890381414f48804201b
- Linux on scratch: https://turbowarp.org/892602496/
- https://github.com/gbdev/awesome-gbdev#emulator-development
- SMS test suite https://github.com/sverx/SMSTestSuite
- GG test suite https://github.com/sverx/GGTestSuite/
- Game boy test roms compilation: https://github.com/c-sp/gameboy-test-roms

Sources

- Game gear by Evan-Amos - Own work, Public Domain, https://commons.wikimedia.org/w/index.php?curid=13317134
- Screenshots from Sameboy https://sameboy.github.io/
- BGB: https://bgb.bircd.org/shots.html
- dmg-acid2 image: https://github.com/mattcurrie/dmg-acid2
- Z80test result on specemu: https://www.spectrumcomputing.co.uk/forums/viewtopic.php?t=752