- 40th Anniversary -

The ZX Spectrum
The Commodore 64

- Chris Smith - Retromania 2022

Chris Smith

- Published game developer for the ZX Spectrum
- Author of “The ZX Spectrum ULA. How to design a microcomputer.”
- CTO of Retro Games LTD and the creator of THEC64 Mini, Fullsize and THEA500 Mini

The Commodore 64

- 1981 - MOS begin designing “next generation” console chips
- Staff pitched a successor to the VIC20 to Tramiel
- Tramiel insisted on 64K.
- Chip (VIC-II and SID) ready by end of November. VIC-40 work starts.

- C64 demonstrated at CES Jan 1982 priced $595 (low chip cost).
- Highest selling home computer. 12-17 million world wide.

The ZX Spectrum

- Same processor allowed use of ROM code from ZX81
- Same gate array (ULA) technology used with ZX81 to reduce cost
- ZX82 developed in six months. Renamed ZX Spectrum
- Released 23rd April 1982, priced £124 (16K), £175 (48K)
- Highest selling home computer in UK.
  Very popular in Spain, EU and Eastern bloc
  (clones)

Popularity

- Lots of friendly school-yard rivalry
- 30,000 ZX Spectrum games / 10,000 Commodore 64 games
  - C64 in US (and DE) - software produced by bigger companies
  - ZX in UK and EU - software produced by indie companies
- ZX was more affordable
- Price war in early-mid 1980s

Commodore 64 - Features

- Full size keyboard
- 64K Memory / 20K ROM
- 300 x 200 resolution. 16 colours. TV RF or composite video out.
- 8 hardware sprites
- 3 channel synthesiser chip with ADSR and filters
- Serial and parallel port, Cartridge slot, Data cassette port
- Two joystick ports
- Restricted BASIC - no graphic or sound commands!

ZX Spectrum - Features

- Rubber keyboard
- 48K Memory / 16K ROM
- 256 x 192 resolution. 8 colours at 2 levels of brightness. TV RF out
- Single channel, one bit speaker
- Analogue cassette port
- Expansion port for peripherals
- Good featured BASIC, not very fast

Commodore 64 - CPU

- 6510 (6502) MOS Technology @ 0.985MHz
- Minimum 2 clock cycles per instruction
- 16-bit PC, 8-bit SP, 8-bit flags and:
  - 1 x 8-bit register, 2 x 8-bit index registers
- First 256 bytes of RAM used for CPU “scratch pad” (page zero)
- CPU and video (VIC-II) contend in character mode (0.927MHz)

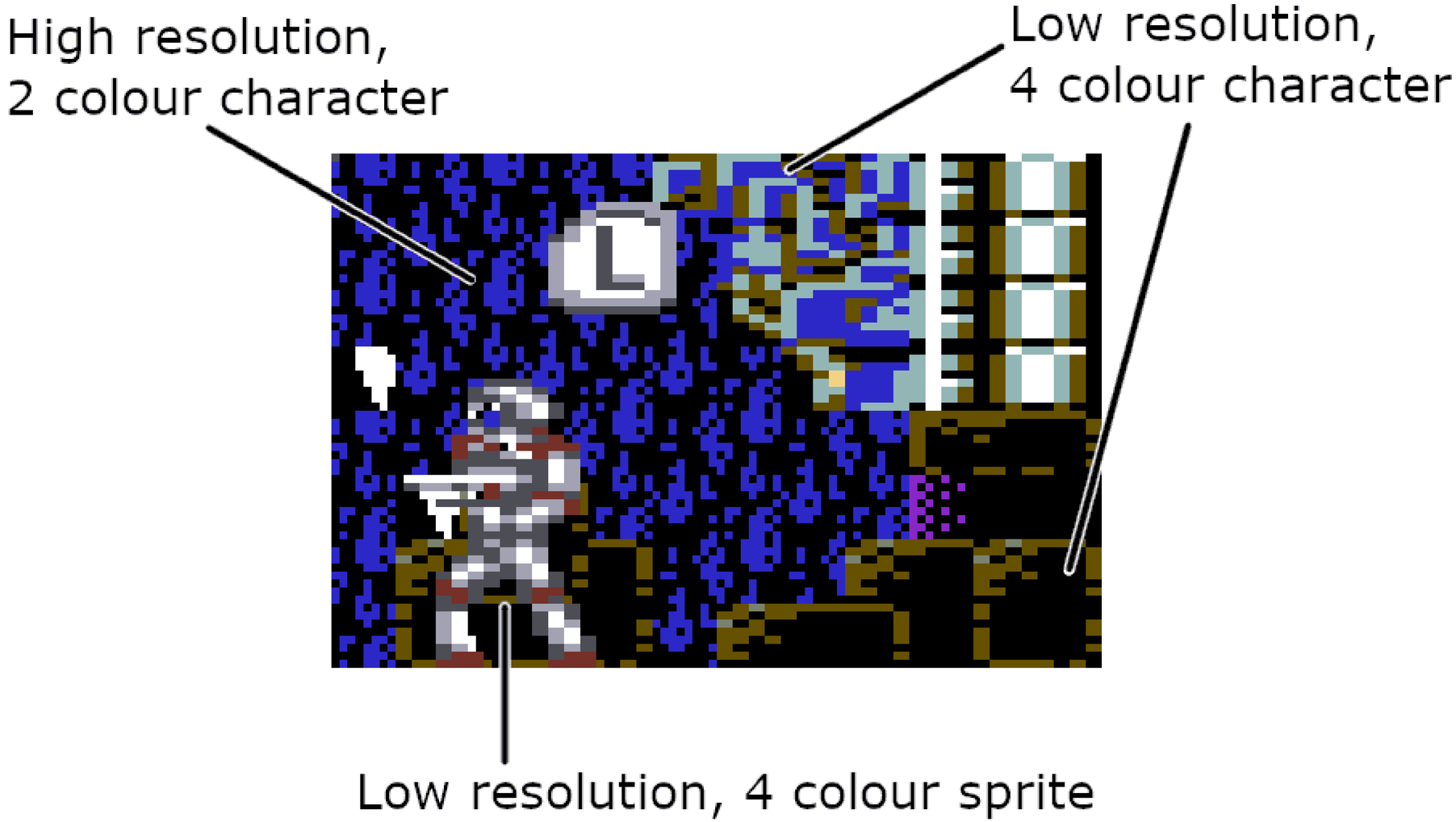
ZX Spectrum - CPU

- Zilog Z80 @ 3.5MHz
- Minimum 4 clock cycles per instruction
- 16-bit PC, 16-bit SP, 8-bit flags and 2 banks of :
  - 7 x 8-bit registers (or 3 x 16-bit registers), 2 x 16-bit index registers
- Provides powerful memory and IO instructions
- CPU and video contend when CPU accesses lower 16K RAM (0x4000)

Commodore 64 - Graphics

- 40 x 25 Character display, low colour 2 per character cell
- 20 x 25 Character display, multi-colour 4 per character cell
- 320 x 200 High resolution, low colour 2 per 8 x 8 cell from 16 colours
- 160 x 200 Low resolution, multi-colour 4 per 8 x 8 cell from 8 colours
- 8 hardware sprites: 24 x 21 single colour, 12 x 21 multi-colour
- Simple hardware scrolling
- Programmable raster interrupt

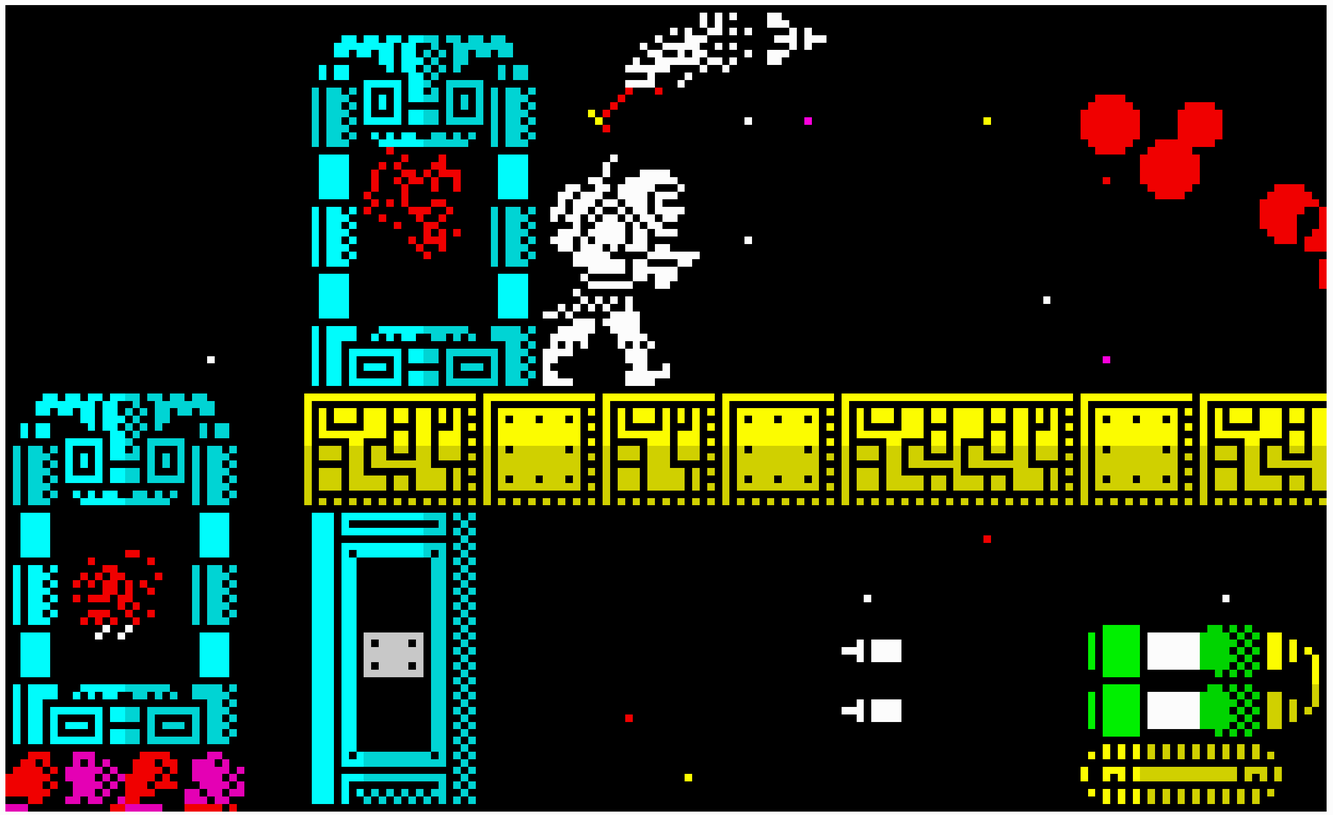
Commodore 64 - Graphics



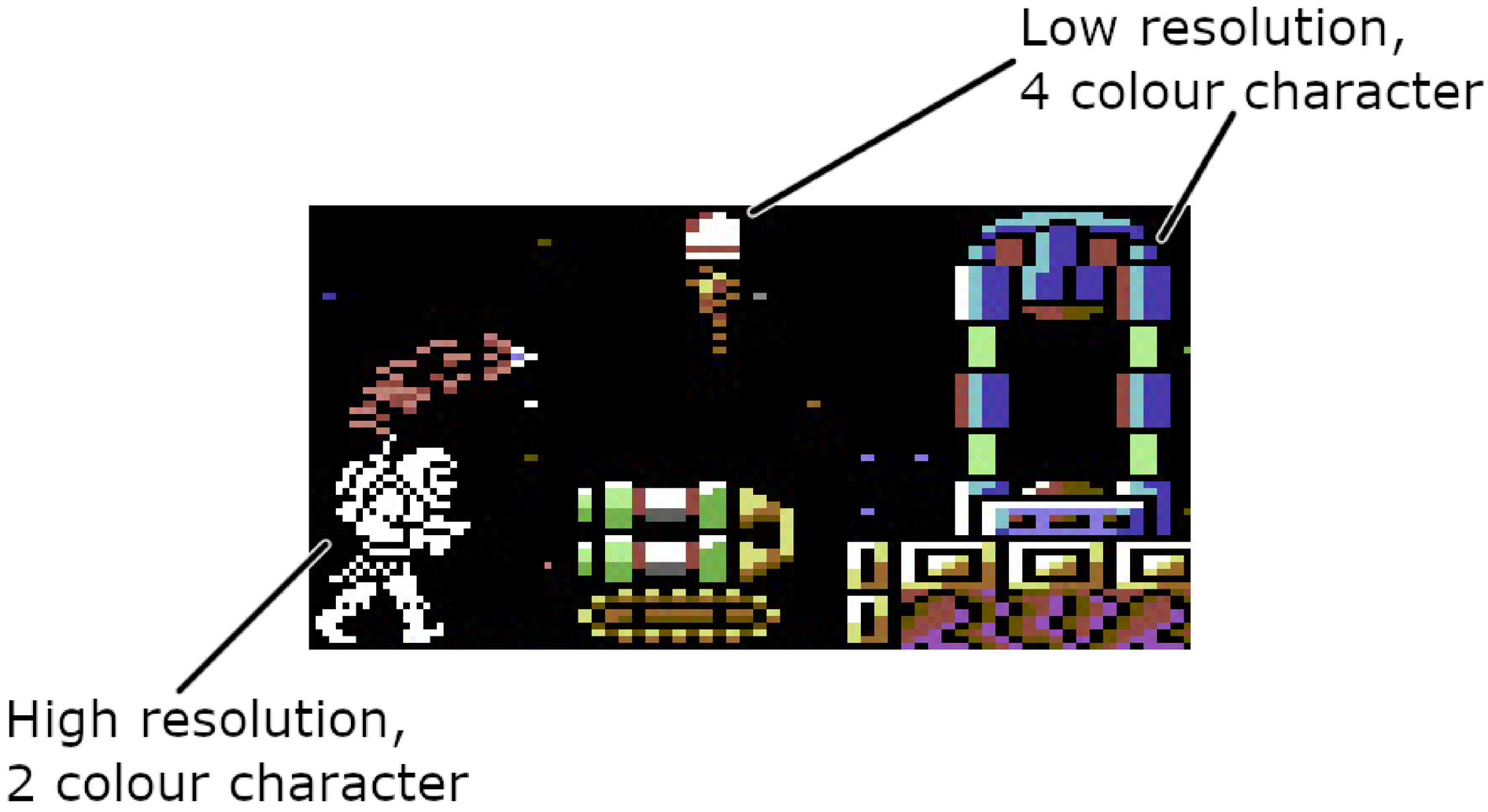
ZX Spectrum - Graphics

- 256 x 192 High resolution, low colour: 2 per 8 x 8 cell, from 8 colours and 2 intensities
- No character modes, no sprites, no hardware scrolling
- Fixed raster interrupt

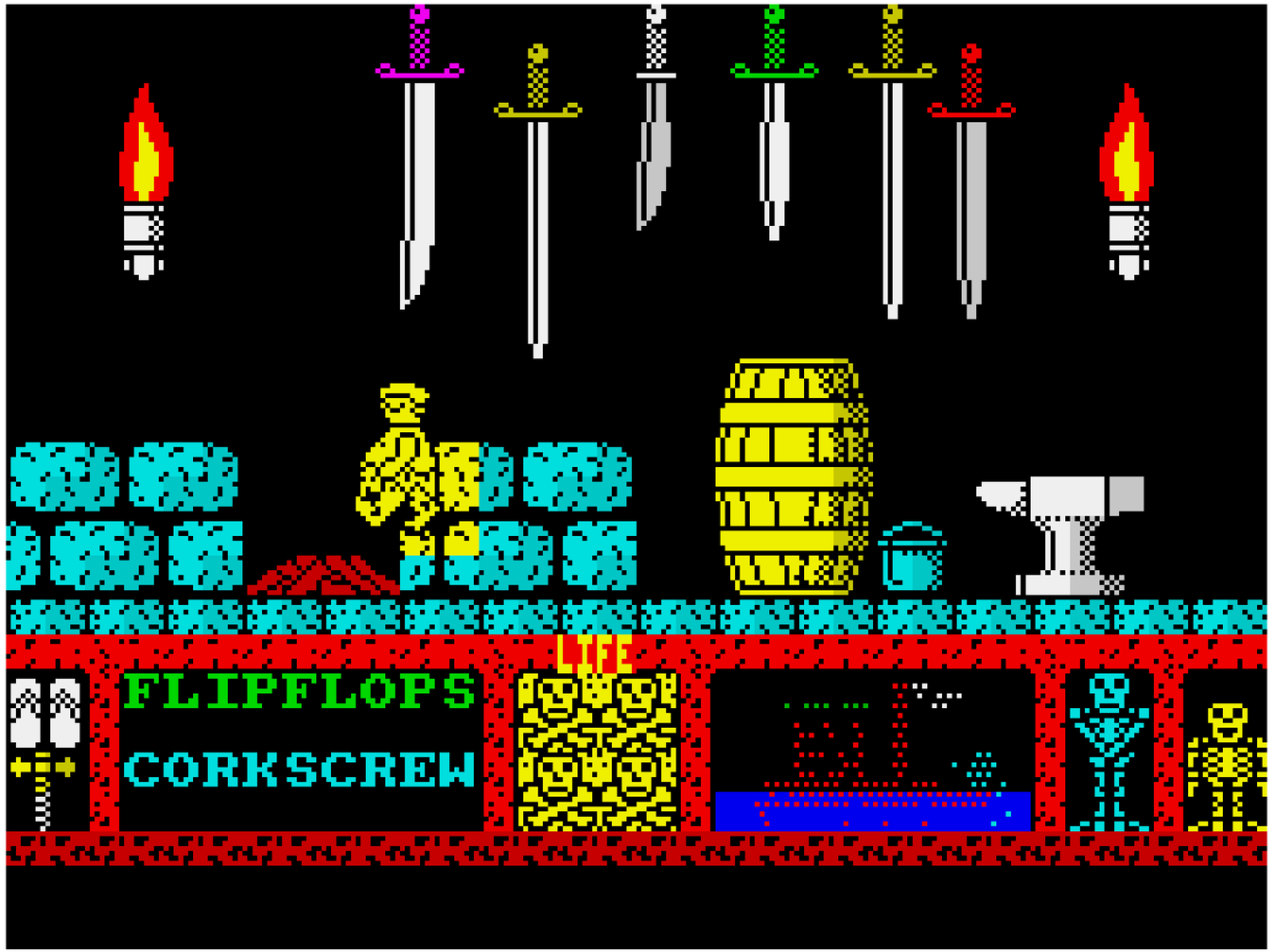
ZX Spectrum - Graphics



Commodore 64 - Exolon



ZX Spectrum - Colour clash



Commodore 64 - Colour clash

- The commodore 64 also had colour clash with its high resolution character modes. Only 2 colours per 8x8 cell.

Simple code example

1. Add the values of two registers together
2. Display result on screen

3. BLUE shows initialisation instructions
4. RED shows memory access

Commodore 64 - Add and Display

```
// Set up two numbers in Page Zero “Registers”
Load A with 3
Store in 0x00 // ZPG location 00
Load A with 5
Store in 0x01 // ZPG location 01

// Add values together, result in register A
Load A with location of ZPG 00
Add contents of ZPG 01 to A

// Convert result to PETSCII code (‘0’ is 48, ‘9’ is 57)
Add 48 to A
```

```
// Display result digit on screen, using character display
Load Y with 0
Store A at 0x400 + Y // Character location 0
```

ZX Spectrum - Add and display

```
// Set up two numbers in registers
Load B with 3
Load C with 5

// Add values together, result in register A
Load A with C
Add B to A

// Convert result to ASCII code (‘0’ is 48, ‘9’ is 57)
Add 48 to A
```

```
// Display result digit on screen
Load HL with 0x4000  // Address of screen display
Load D   with 0x3D   // High address of character set

// Point a digit in character set
Shift A left by three bits // Multiply by 8
Load E with A              // Low address of character set

// Transfer character onto screen, 8 rows
Load B with 8
LOOP:
Load A from memory at DE
Store A into memory at HL
Increase H                 // Next display pixel row
Increase E                 // Next character row
Decrease B
If B not zero, repeat LOOP
```

What does this mean?

On the Commodore 64:

Straightforward to create sprite and scrolling based games.
Programmers didn’t need to think creatively, games didn’t generally push boundaries.
Notable advances: Uridium, The Last Ninja, Armalyte, Turrican II

On the ZX Spectrum:

Every game pushed boundaries.

“There is nothing to work with, so you are free.
It sorted the men out from the boys, programming wise.
You had to put the effort in!”

Joffa Smith (Cobra, Green Beret)

Comparison of CPU and graphics

- ZX Spectrum had a faster and more flexible CPU
  - Could support a wide range of game styles.
  - Always high resolution and could not avoid colour clash.
  - Direct graphic manipulation ✓ Scrolling
- Commodore 64 had hardware supported graphics
  - Could do certain styles of game extremely well, others poorly
  - Mixing graphic styles and using lower resolution avoids colour clash.
  - Sprites and scrolling ✓ Direct graphic manipulation

Sound

- The Commodore 64 had an advanced 3-channel synthesiser chip
- The ZX Spectrum had a built-in 1-bit speaker

Commodore 64 - SID

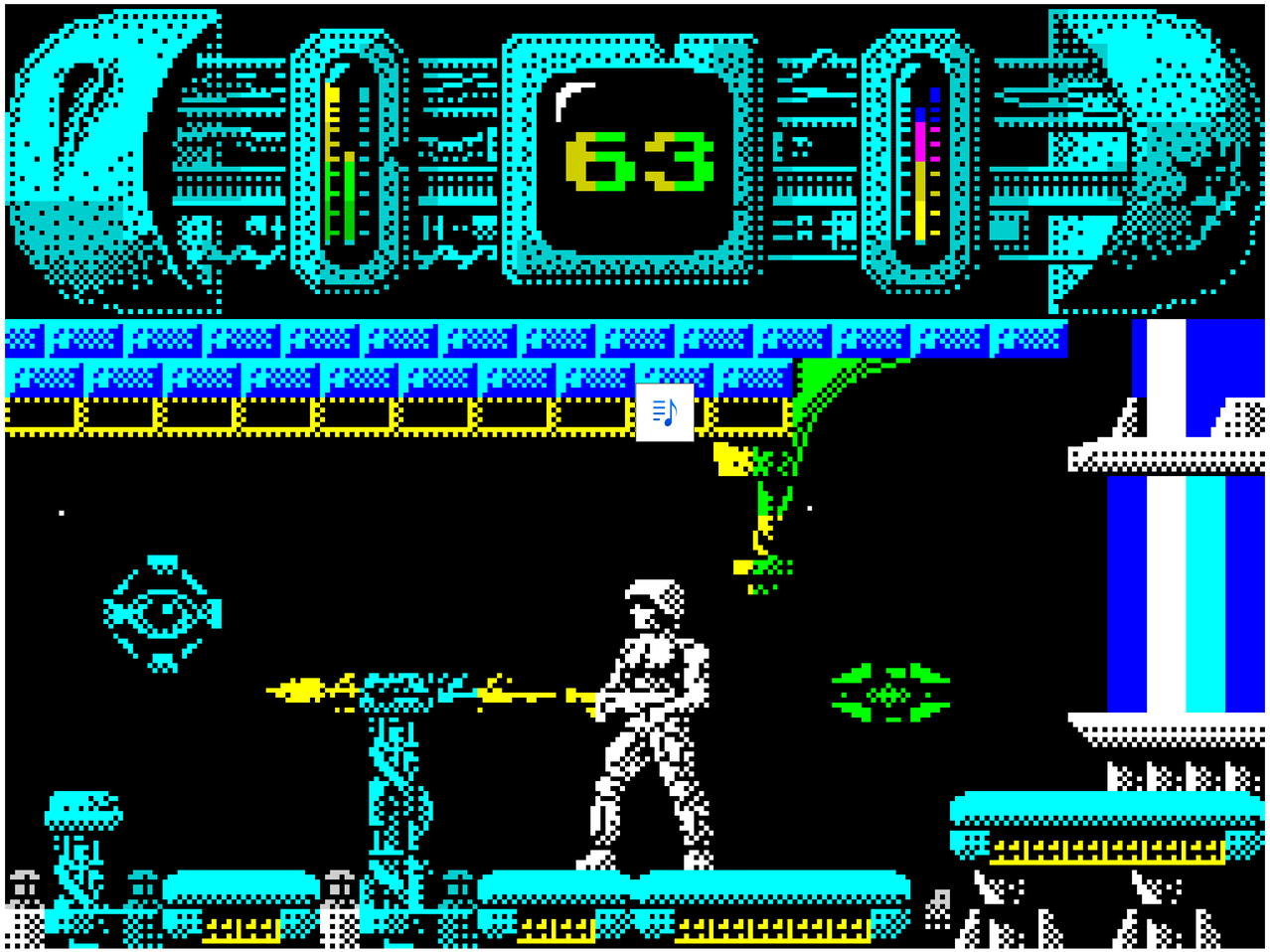
- The SID chip (Robert Yannes):
  - Three oscillators (variable duty, sawtooth, triangle and noise)
  - ADSR envelopes
  - Analogue filter
- Sound was independent of the CPU
- Only home computer with a synthesiser chip

Commodore 64 - SID

ZX Spectrum - Beeper

- Simple speaker connected to a single pin of the ULA
- Speaker could be moved by altering the on/off state of the ULA pin
- Sound generation requires the CPU to move the speaker - Single tone
- Clever developers combined multi on-off sequences in software to produce multi channel audio

ZX Spectrum - Beeper



ZX Spectrum - Beeper

Interfaces

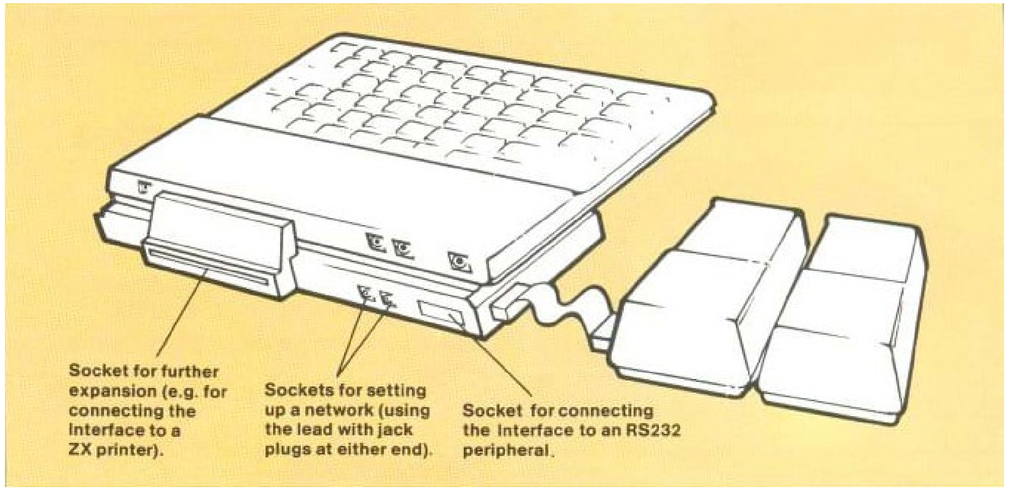
- The Commodore 64 has 6 different interfaces built in
  - Required a datasette (£45) or disk drive (£220 / $399)
- The ZX Spectrum had an expansion port and cassette deck interface
  - Required a cassette recorder (£15)

Commodore 64 - 1541 Disk Drive

- Connected to the IEEE-448 serial port
- Compatibility with 1540 meant slow serial data rate (300B/s)
  - ~10 minutes to read 35 track disk - 170KB capacity.
- Custom software could achieve up to 4000B/s
- Third party interfaces increase speed
  - Most not 100% compatible

ZX Spectrum - Interface 1

- The ZX Interface 1 expansion released1983 at £49.95
- Provided Microdrive, RS232 and LAN
  - Microdrive - Continuous tape look.
    85K Storage. Speed = 15,000B/s
  - RS232 supported printers and modems
  - LAN connected up to 64 ZX Spectrums



ZX Spectrum - Interface 2

- ZX Interface 2 - 1983 at £19.95
- Connects 2 joysticks, 1 cartridge slot
  - Pass-through expansion port only allowed ZX Printer connection
  - Cartridges cost £14.95
    - Ultimate 16K games and Sinclair 16K games

Interfaces - Conclusion

- Commodore 64 had better interfaces out-of-the-box:
  - Most important: Joystick, cartridges
  - Reliance on restricted IEEE-448 interface
- ZX Spectrum had limited interfaces
  - Innovative market for third-party joystick and disk solutions
  - Incompatibilities but good performance

Overall

- There is no winner. They did what they did… differently…
- Software advances on one inspired advances in the other
- Between them the most worlds most popular home computers
- Kickstarted the software and games industry
- Many of the younger owners now lead today’s IT industry
- They are both fun, challenging and inspiring to code for and play today!

Thank you

Questions?