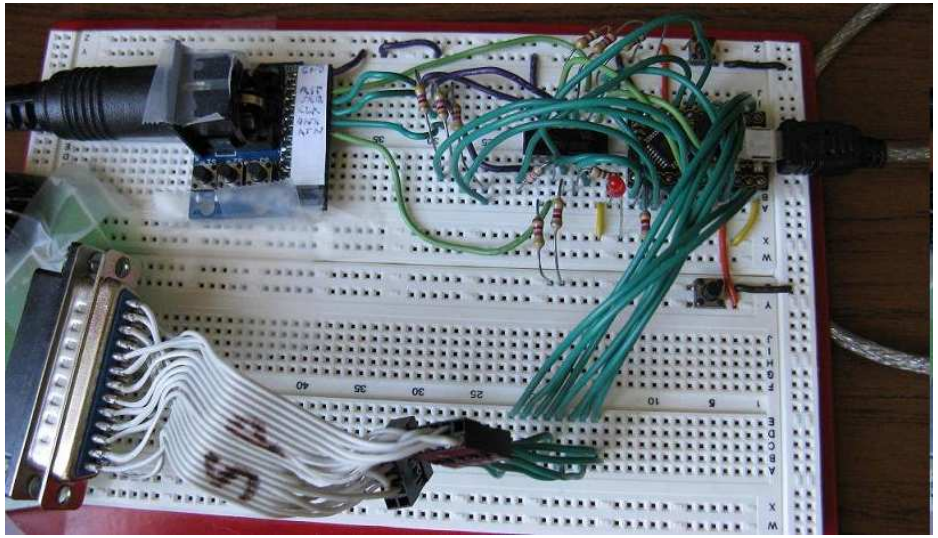
Building the ZoomFloppy



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Overview

- Commodore floppy drive architecture
  - How the drive works
  - Copy protection schemes
- The old way to interface a 1541 and PC (printer port)
- USB interfacing: the new way
  - xu1541 (2007)
  - xum1541 (2009)
- Creating the xum1541 firmware
- Building the ZoomFloppy

Commodore floppy drive architecture

- The first dual CPU home computer was not the C128 (apologies to Bil Herd)

- 2040 dual drive
  - 6502 to talk to the host
  - 6504 to do access the media (GCR encoding)
- IEEE-488 (GPIB) interface to PET

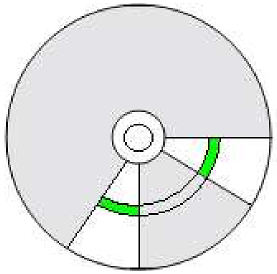
Commodore floppy drive architecture

- 1541 series (1540, 1541-II, etc.)
  - Cost reduction is a kind of performance
  - IEC bus is cheaper serial version of IEEE-488
  - Merged both CPU functions into one with interrupt-driven task queue
- 1571 series
  - Multiple floppy formats (MFM)
  - Burst mode using SRQ line

Copy protection schemes

- Best ones depend on the hardware limits of drive

- 1541 limits
  - 2 KB of RAM, 8 KB ROM
  - No index hole sensor (soft-sectored)



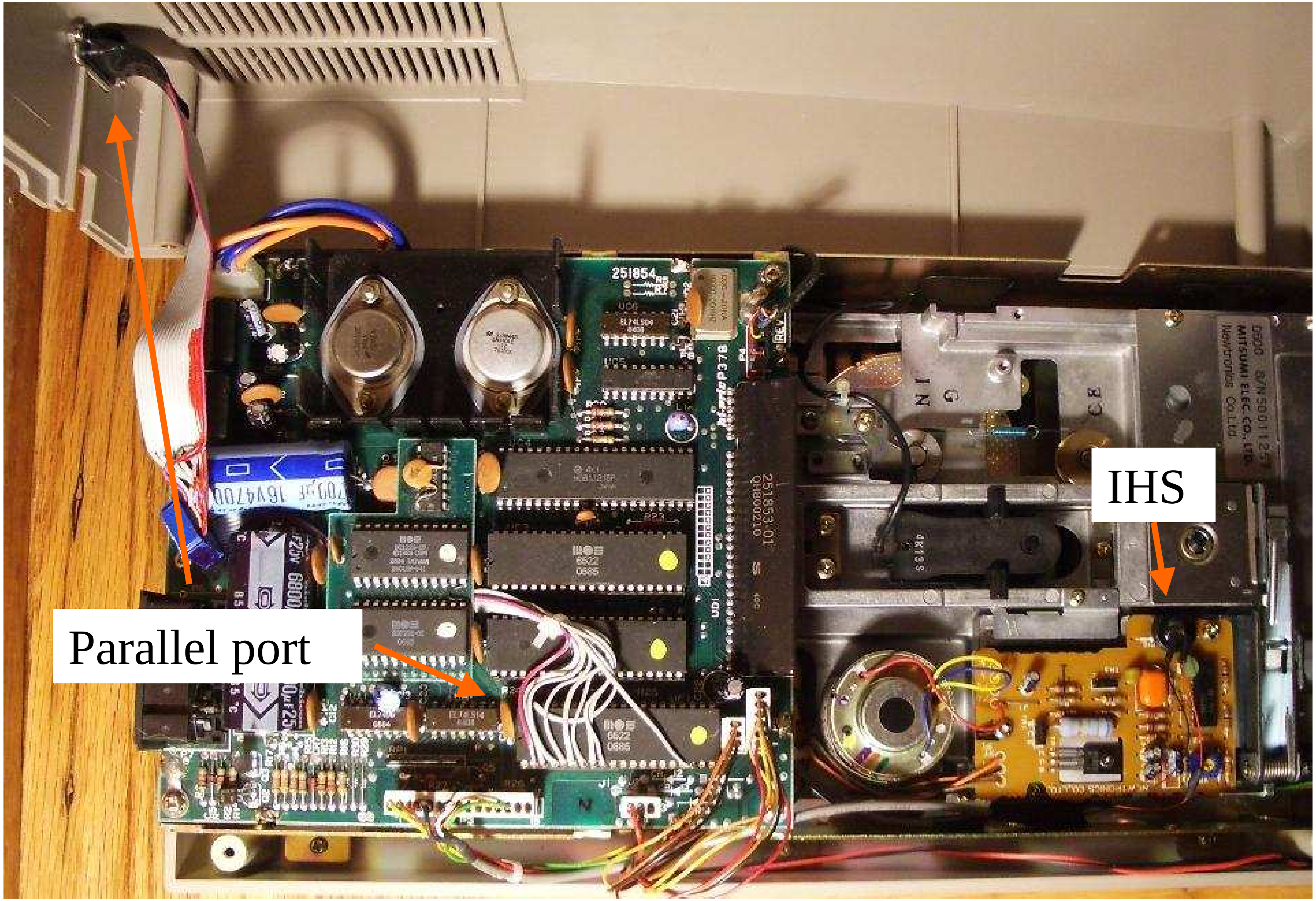
- Whole-track custom format (RAM too small)
  - v-max: fully custom encoding, 10-bit sync marks
  - Epyx (newer)
- Track sync (no IHS)
  - Bump head between tracks and verify data found at proper location
  - Fat tracks (Activision, EA, RapidLok)

Copying protected floppies

- As opposed to cracking protection schemes
- Hardware mods
  - Maverick 8 KB drive RAM expansion
    - Store entire track at once in drive, stream back to host
    - Detectable by checking mirrored addresses
  - Burst Nibbler parallel cable
    - Attaches to unused 8-bit port on VIA
    - Sends one byte at a time, sufficient for full media bitrate
  - Add an index hole sensor
    - 1571 has one built-in for MFM mode
    - Or clever in-drive timer routines

- nibtools/mnib have support reading and writing protected disks
  - Thanks to Peter Rittwage and Markus Brenner

1541 hardware mods



Parallel port

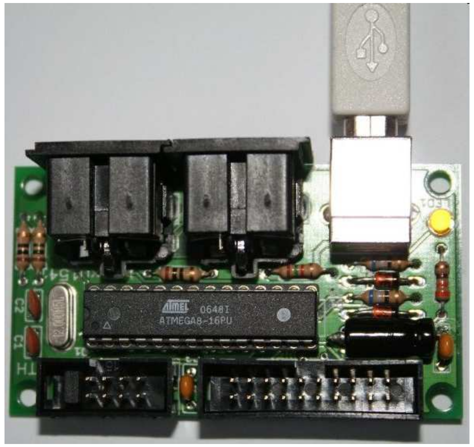
IHS

Interfacing with a PC (old way)

- Printer port (LPT)
  - 8 bits bidirectional plus handshake signals
  - Perfect for IEC bus control + parallel transfer
- Problems
  - XA1541, XM, XE, X, P-variants, too many!
    - Caused by evolving and differing voltages on PC ports
    - Opposing goals of low cost vs. functionality
  - Doesn’t exist on modern PCs and laptops
    - Also Mac hardware
    - Anything non-x86
  - Fast and low-latency, but too slow for some tricks
    - 1 µs per access (1 MB/sec max)

xu1541

- USB floppy interface by Till Harbaum
  - Cheap
  - All through-hole parts so easy to build
  - Open-source and works well



- Limitations
  - Slow
    - Software USB decoding
    - Serial slower than with an X-cable, parallel transfers as slow as serial
    - Can’t support parallel nibbling and limited RAM so no copying protected floppies
  - USB control transfers only
  - Not readily available

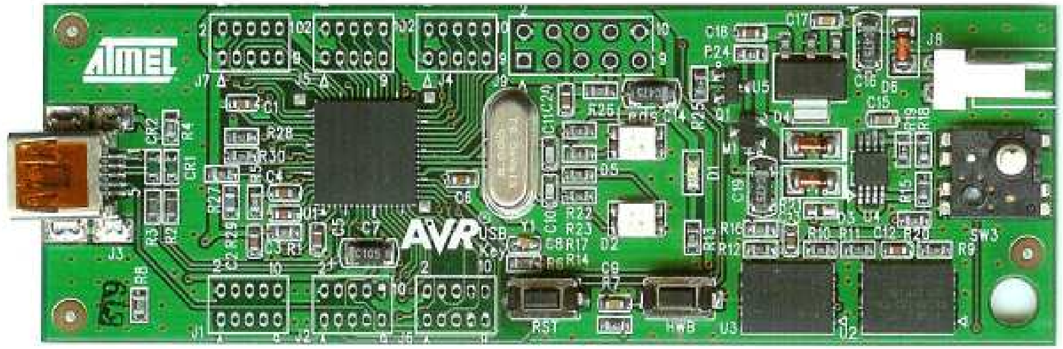
- Good for its time, especially if you just want to transfer files to unprotected disks

Enter: me

- In 2005, got an XAP1541 and began archiving floppies for C64Preservation.com
  - “Just how did some of those more complicated copy protection schemes work anyway?”
  - Reverse-engineered from original image using VICE drive monitor
- Contributed some fixes to nibtools
- Then PC with DOS and printer port died

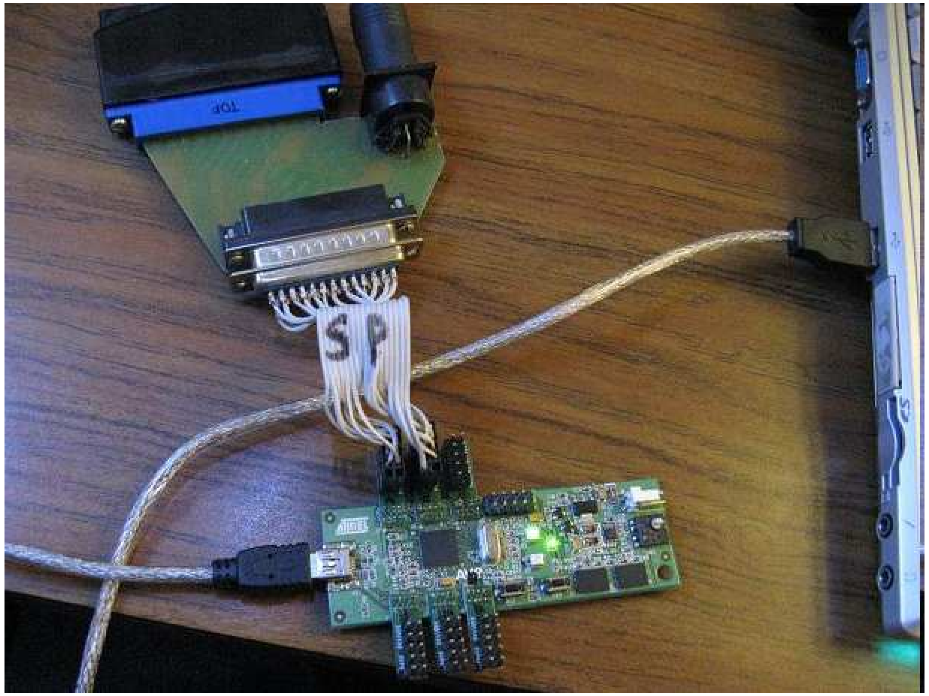
xum1541

- 2008: “Hey, there’s this new Atmel microcontroller with hardware USB support”
  - Ported xu1541 firmware to the AT90USB, replacing the software USB stack with hardware routines
    - OpenCBM plugin interface so standard tools all work
    - LUFA library by Dean Camera was very helpful
  - AT90USBKEY devel board: $30
    - Built a custom cable to connect to existing XAP1541
    - No PCB design or difficult soldering, just a cable



xum1541

- More debugging and announced Jan. 2009
- Problems
  - Works fine but have to replug if USB transfer interrupted (^C)
  - No nibbler support, control messages too small for USB overhead (8 bytes each)
  - Only two people built cable (Womo and Christian V.)



xum1541

- New USB protocol
  - USB bulk transfers (32 or 64 bytes)
  - Inline byte handling (no bucket brigade in RAM)
  - Start/end markers to detect interruptions and reset cleanly
- Finished on train in Europe (fall 2009)
  - Fast d64copy
  - nibtools works!
- Problems
  - Infinite listener hold-off
    - To support printers or other slow devices, you have to wait forever for drive to respond
  - 3.3v level mismatch gave some idle current but still safe
  - Still only two users

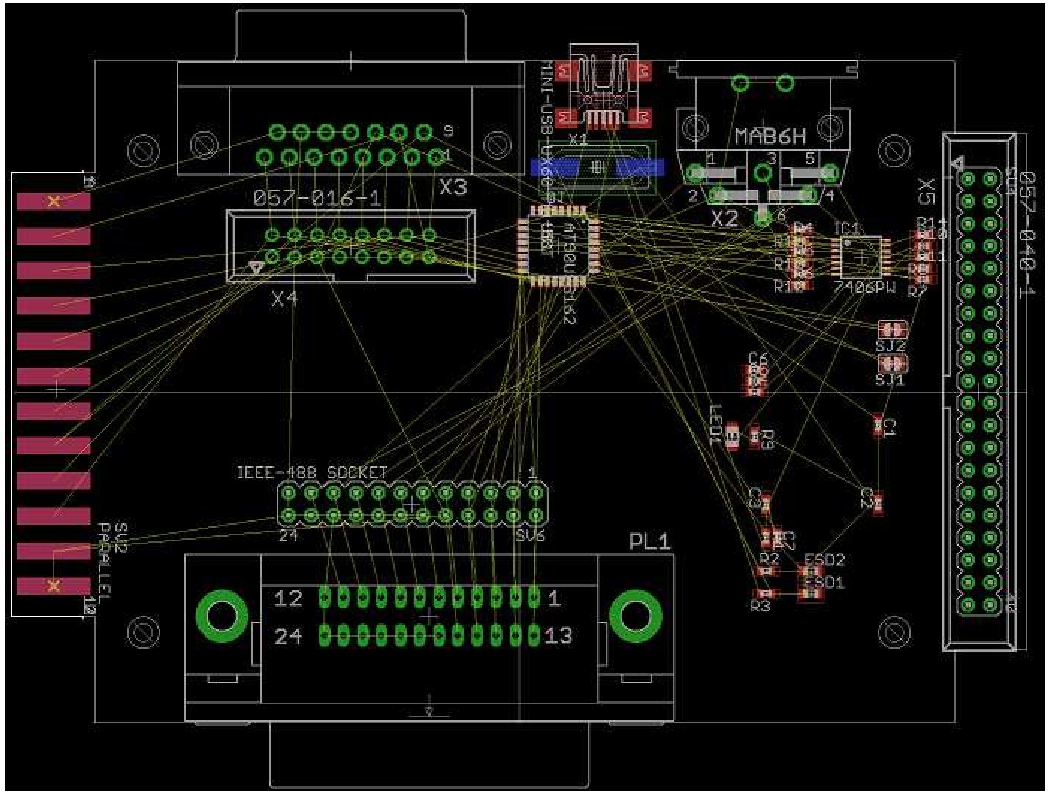
Building the ZoomFloppy

- Daughtercard approach
  - New Bumble-B board: $15
  - Would have plugged into this IEC/parallel adapter
  - 7406 for bus isolation

- Assembled several prototypes and works well
  - "Anyone want to build this thing?"
    - Jim Brain: "ok"

Building the ZoomFloppy

- Fully custom PCB by Jim Brain
  - Connectors for IEC, parallel (multiple)
  - Connectors for future IEEE-488 support
  - Fits in a nice enclosure
  - Packaged and for sale (hopefully, soon)



IEEE-488 future support

- Implemented in the XS-1541 currently
  - Thomas Winkler created this device
- Future support planned in xum1541
  - XS-1541 is open source so we can use its routines
  - Autodetect for different cables already designed in
  - ZoomFloppy has connector pads for it

Teaching the 1571 new tricks

- 1571 is quite an interesting device
  - Multi-mode like a C128
    - 1541 compatible (1 MHz, 2 VIAs)
    - 1571 (2 MHz, 2 VIAs, 1 CIA)
    - MFM (WD 1770)
  - Index hole sensor

- Burst mode
  - SRQ is previously unused IEC line
  - Reads at 3.5 KB/s over serial bus but only to C128, writes at old 400 bytes/s rate
  - Backwards-compatible with original transfers
  - Looks interesting, but we need 40 KB/s to keep up with the drive’s raw bitrate

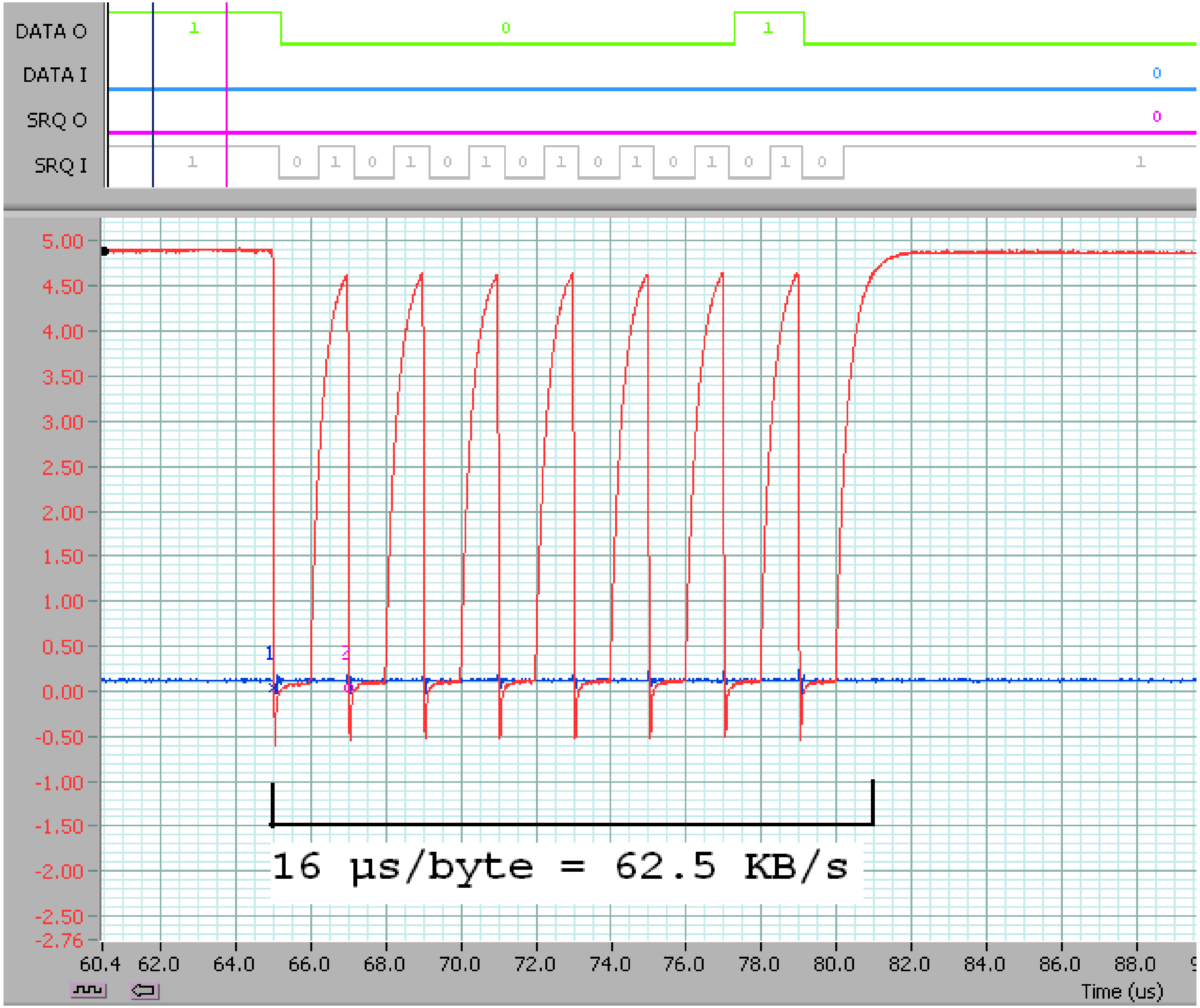
Is it possible?

- We need 40 KB/s (25 µs per byte)
  - Plus a few clock cycles to read a byte from the shift register, toggle handshake lines, loop

- Max CIA transfer rate
  - “Theoretically it is even possible to realize bus transfers at up to 60,000 bytes per second with the C-128’s fast bus hardware.” (*1571 Internals*, p. 148)
  - Max parameters
    - External clock: 2 MHz
    - Count down timer: start at 1, toggle output on 0
    - 500 Kbits/s (2 µs period)

- Theoretically, it is possible to transfer at 62.5 KB/s, leaving some overhead room

Apparently this is possible



16 µs/byte = 62.5 KB/s

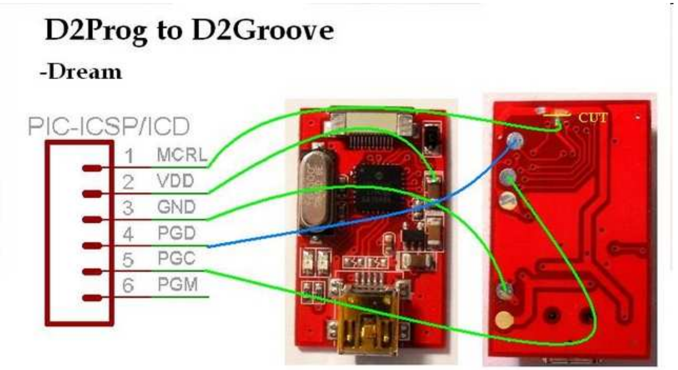
Implementing SRQ nibbling

- A lot more work to do before ready to release
  - Implement drive code
    - Lots of changes needed in 1571 mode like different sync detection
    - Want to keep index hole sensor support also
  - Modify nibtools to load separate IO routines based on drive capabilities
    - Need to autodetect missing SRQ line
    - Fall back to parallel mode automatically

- In the end, all Commodore protected floppies could be archived and remastered with a ZoomFloppy + 1571
  - No hardware mods

Thwarted by Playstation 3 hacking

- Final PCB almost complete, looking for parts suppliers
- Then PS3 USB exploit released
  - Just happened to use the same Atmel chips as us
  - Supply went from “great” to “none” in weeks
    - AT90USB162: Dec 5 2010 delivery
    - ATmega16U2: Nov 15 2010 delivery
- Hey, pirates, there are other exploit delivery methods
  - D2groove: D2Prog (PIC18F)
  - Dingoo A320 console
  - TI-84+/SE calculator
- Note: we don’t condone piracy
  - But get off my lawn!



Conclusion

- xum1541 firmware already available (GPL)
  - Fast IEC transfers
  - Even faster transfers and nibbling with parallel cable
  - Easy to build if you have some soldering skills
  - Stable and well-tested
- New firmware features on the way
  - SRQ nibbling on the 1571
  - IEEE-488 drive support
- ZoomFloppy should be available for sale soon!

  http://root.org/~nate/c64/xum1541

  http://jbrain.net/

- Many thanks to: Wolfgang Moser, Christian Vogelsgang, Jim Brain, Peter Rittwage, Spiro Trikaliotis, Thomas Winkler, Joe Forster, Till Harbaum, C64Preservation.com, OpenCBM