

How to Make an Eight Bit Computer and Save the World!

Braddock Gaskill
Humane Informatics
braddock@braddock.com





Talk Overview

•*Today's Audience*

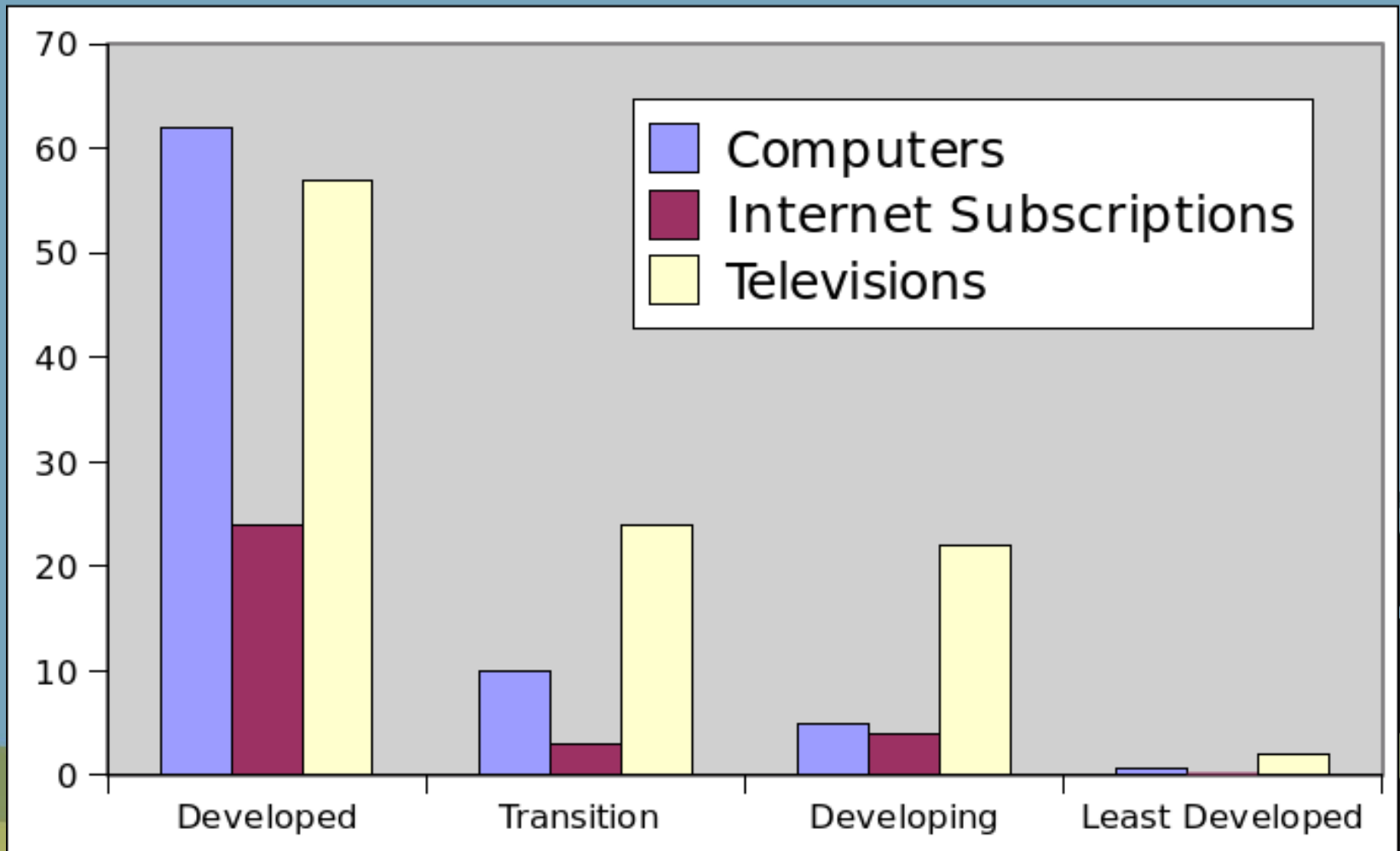
- ~~Independently Wealthy Philanthropists~~
- ~~Non-Governmental Organizations, UN, etc~~
- ~~DoD Civil Affairs, USAID~~
- Geeks** interested in
 - Playing with **Microcontrollers**
 - Building & Fabricating** things
 - Open Source **Tools** and **Hardware**

•*Today's Talk*

- Overview and **demo** of device
- Survey of AVR Open Source **Hardware**
- Survey of AVR Open Source **Tools**
- Walk through of **design and design tools**
- Walk through of **fabrication and manufacturing**

Bridging TV/Internet Gap

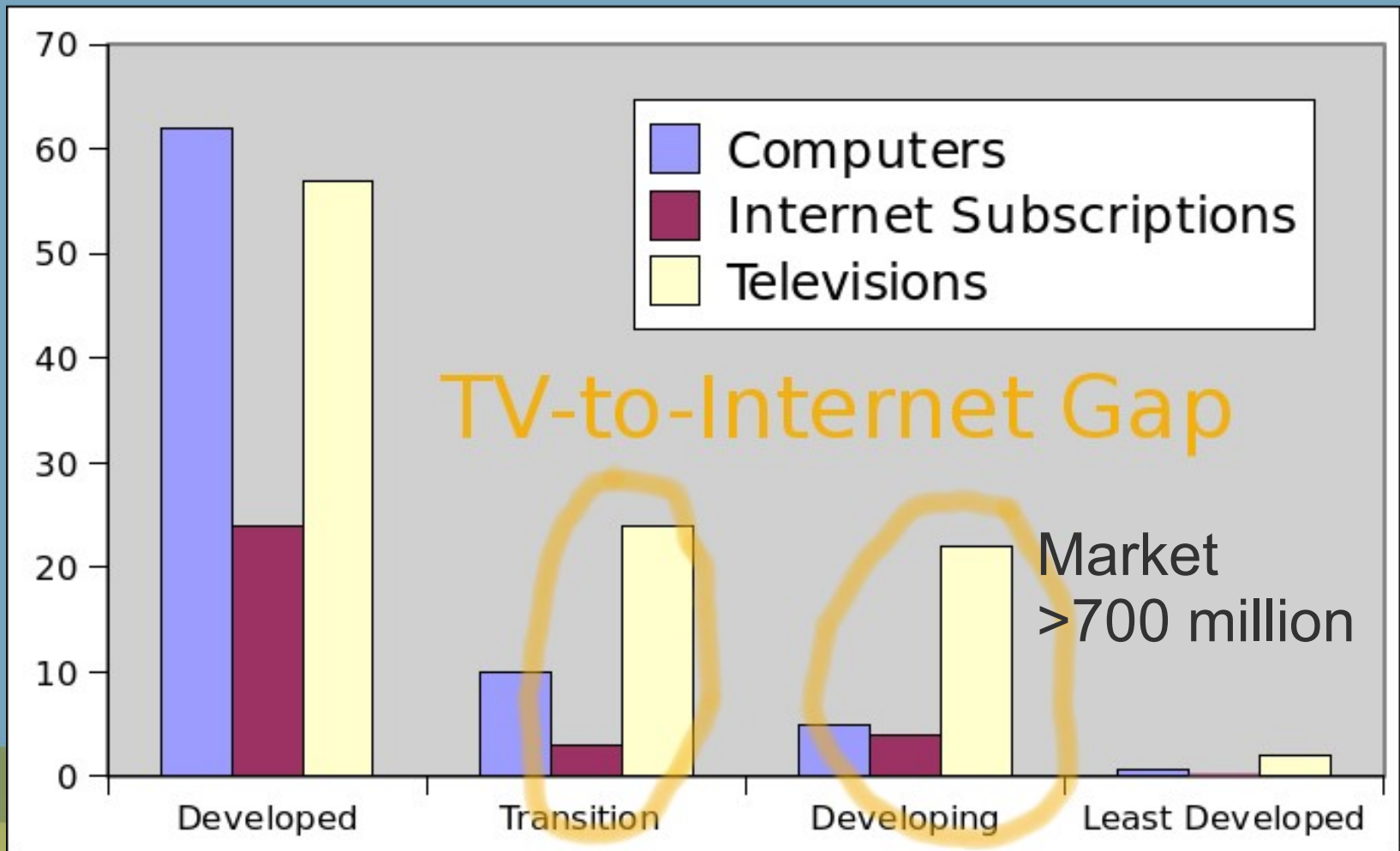
Global Information Access per 100 Inhabitants



"The Global Information Society: a Statistical View", 2008

Bridging TV/Internet Gap

Global Information Access per 100 Inhabitants



"The Global Information Society: a Statistical View", 2008

Pitch

- **2GB SD Card** = **~5,000 books** or better part of **Wikipedia**
- **Humane Reader** device turns any **TV set** into an e-book/wikipedia reader.
- **Production Cost** approx **\$20** (incl SD Card)





Value Proposition

- ***The Humane Reader can provide a virtual library to any developing world school or individual with electrical power for less than the cost of a single textbook.***



Secondary Goals

- Goal:** Create an extendable, hackable, 8-bit general computing platform both for first through third world developers and experimenters.
- Effect:** Join and leverage the existing open source hardware community (Arduino, AVR, etc) to spur further development.
- Effect:** Provide a learning platform as well as simple e-book reader.



Demo

DEMO



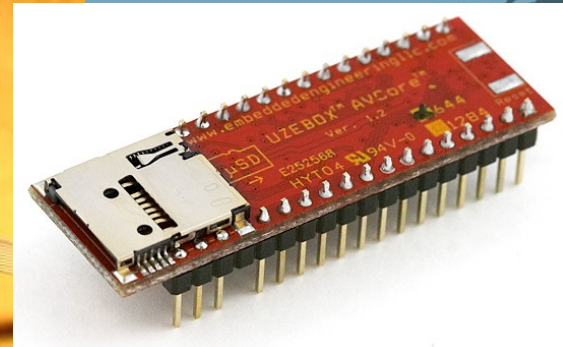
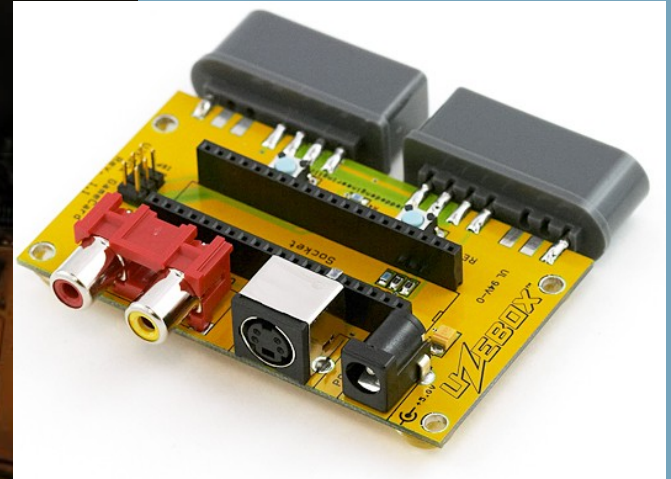
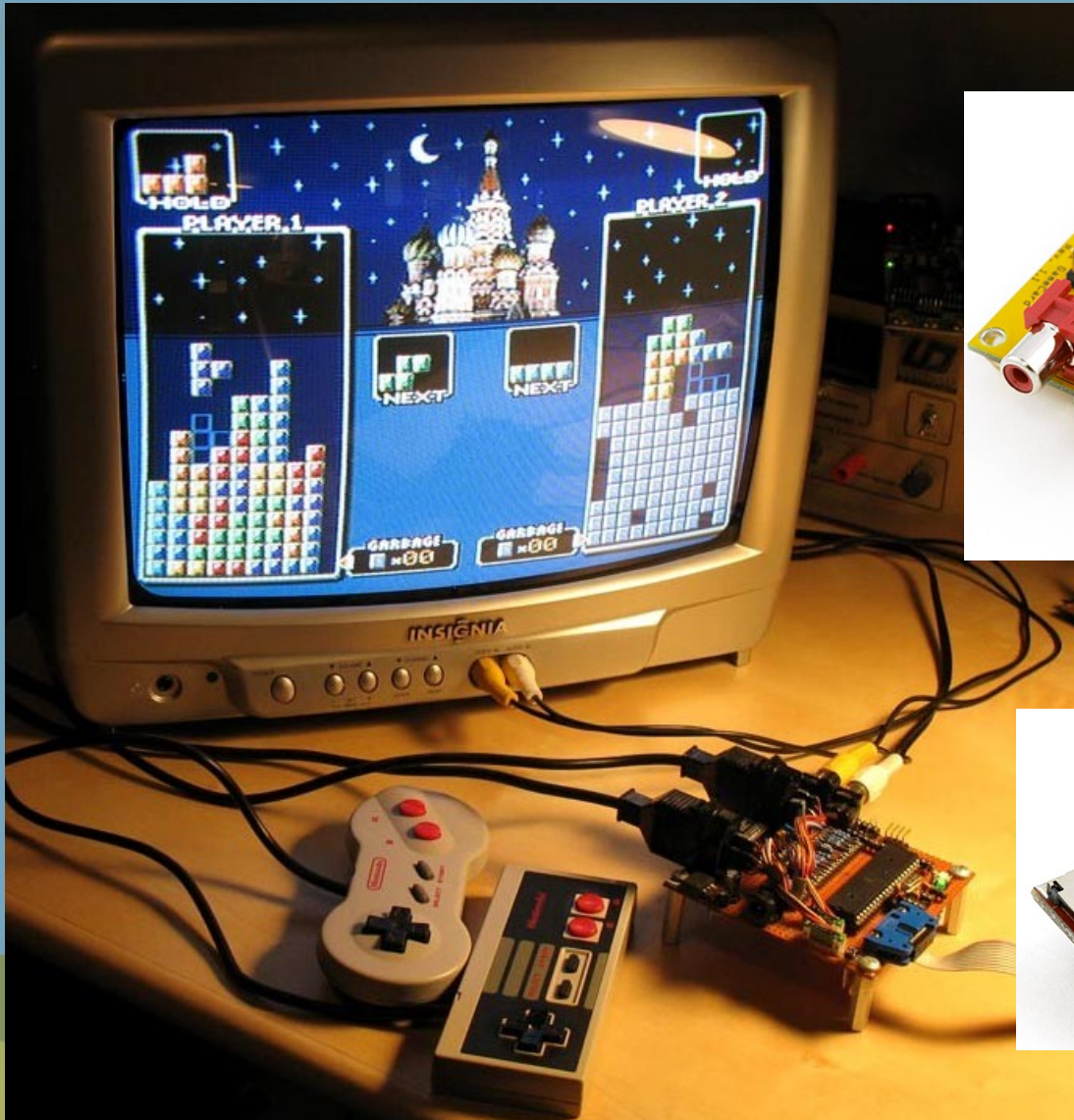
humaneinfo.com



Design Requirements

- *NTSC/PAL Video Output*
- *SD Card Interface (w/FAT)*
- *Cheap Input Interface (buttons)*
- *Power (Micro-USB Adaptor)*
- *PS/2 Keyboard Interface (optional)*
- *USB interface (optional)*
- *Audio (optional)*
- *IR (optional)*

AVR Open Ecosystem: Uzebox





AVR Open Ecosystem: **Uzebox**

- *8-bit gaming "console"*
- **FEATURES:** *NTSC/PAL color video output, game controller input, SD Card, custom "kernel", solid community*
- **FAILURES:** *expensive video chip, expensive MCU (Atmega644), overclocked design*
- **Too Expensive (\$95 sparkfun)**



AVR Open Ecosystem: Arduino

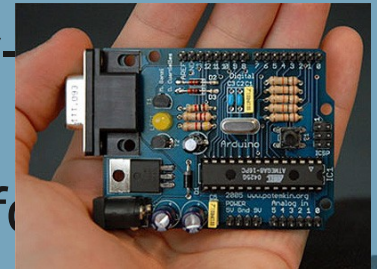
- **HARDWARE:**

- Simple break-out board with pseudo-standard expansion headers
- Wide variety of extension "shields" - Ethernet, Wifi, Bluetooth, SD Cards, video

- **SOFTWARE:** Provides an educationally-oriented "easy" IDE.

- **COMMUNITY:** Excellent. Dev tutorials, forums, etc

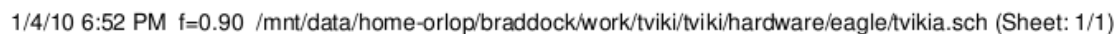
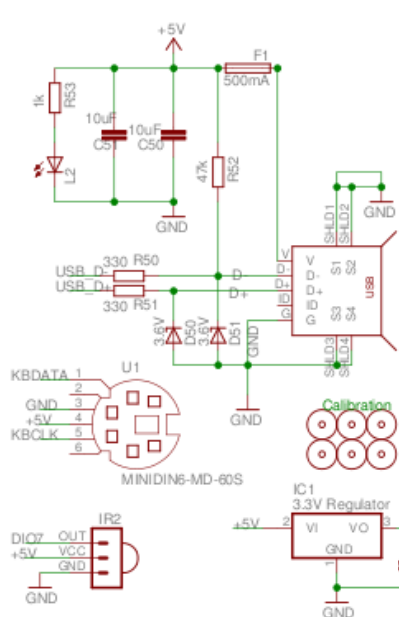
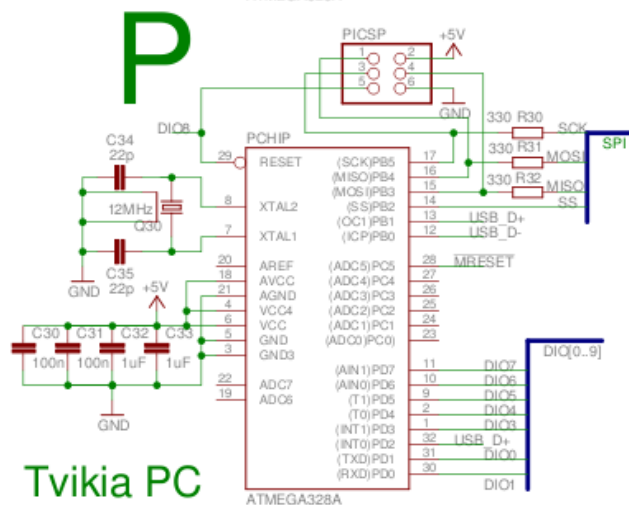
- **CONCLUSION:** Shield, IDE, and software compatible.





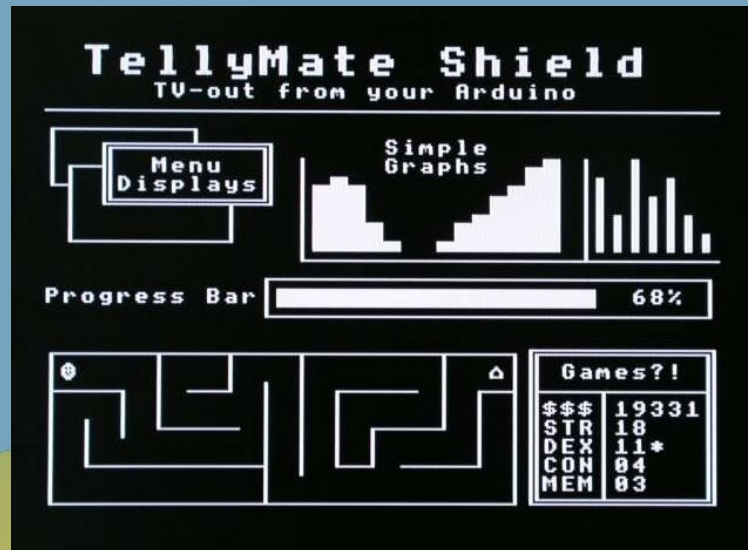
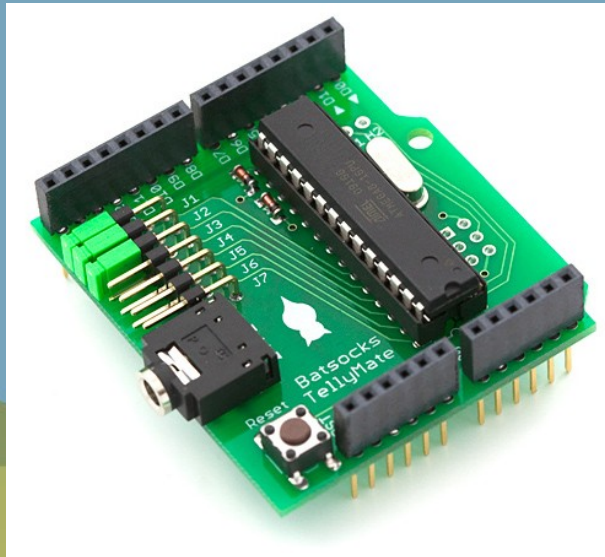
AVR Open Ecosystem: Tools

- **avr-gcc** compiler - full C, partial C++, bintools, well supported alternative to Atmel's compiler
- **avr-libc** - standard C library for AVR. Includes printf, etc (roll your own IO backend)
- **avrdude** - OSS Programmer - many methods
- **simulavr emulator** - several OSS emulators - waste of time (?)
- **avarice** - JTAG debugging. HW Expensive. Glitchy (-Os). AVR Dragon for <32k MCUs.



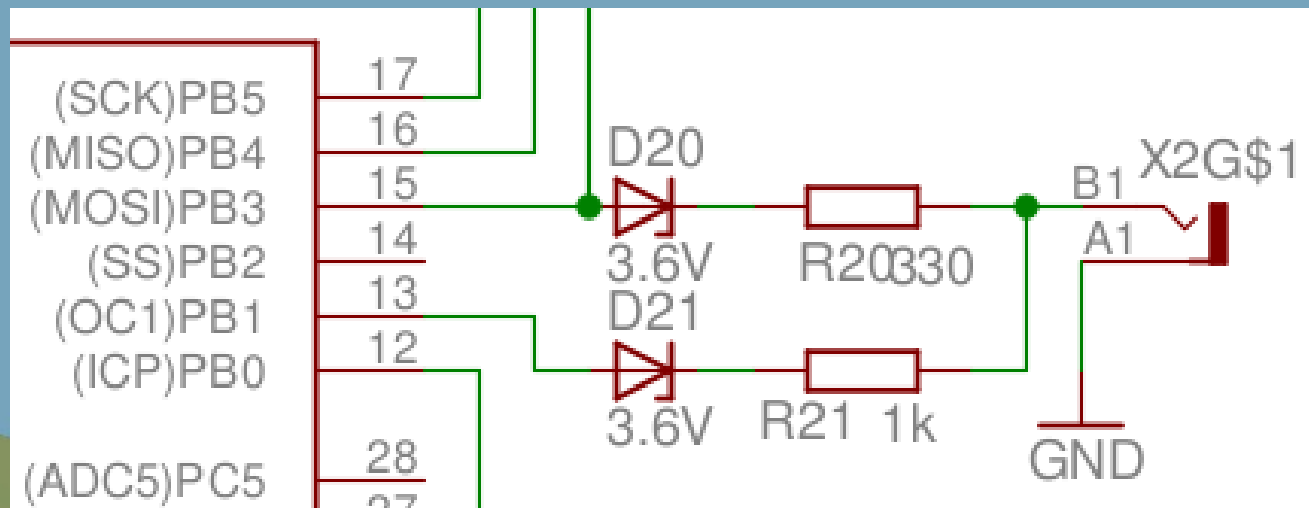
Video Output

- **REQ:** NTSC/PAL Video Output
- **PROBLEM:** Very fast signal. For B&W, only a few cycles per dot.
- **SOLUTION:** Use existing Tellymate project software.



Video Output

- ***SOLUTION:*** Use existing Tellymate project software.
- Tellymate uses MCU's SPI device to output 9 dots at a time (~22 cycles per SPI buffer load @16MHz).





SD Card Requirement

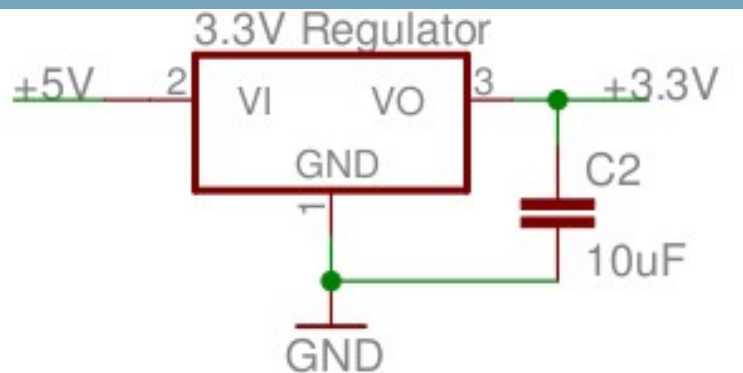
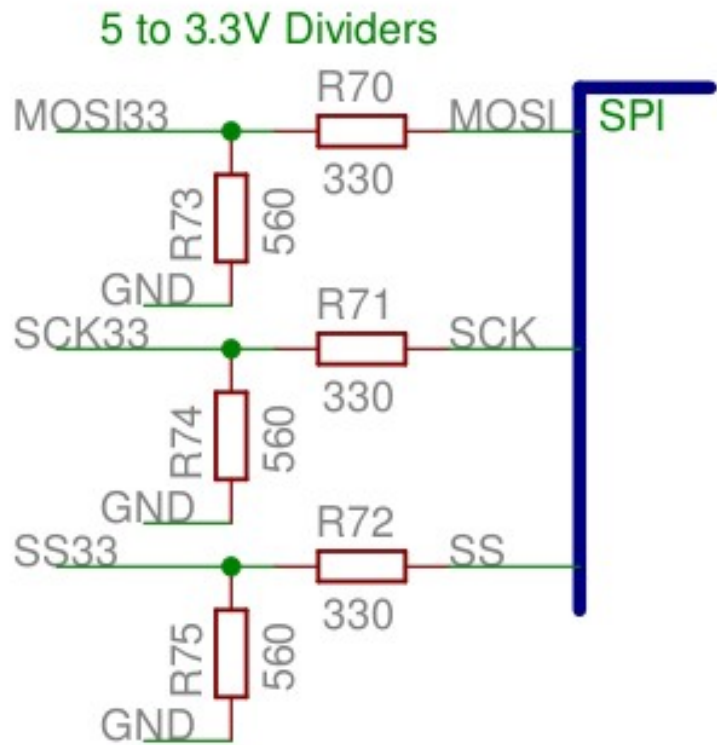
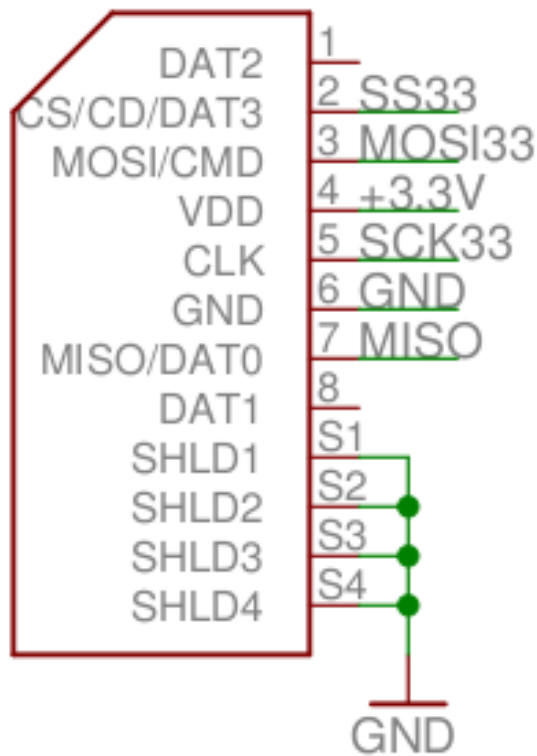
•*Interface:*

- SD Cards have a simple 4-wire SPI hardware interface.
- 3.3V signal levels
- SOLUTION:** 5V to 3.3V voltage dividers for MCU output, MCU can discern 3.3V input

•*Power:*

- SD Card needs 3.3V power
- theoretical (but not observed) current requirements are high.
- SOLUTION:** Add 3.3V regulator
- 3.3V handling "inspired" by Uzebox schematic

SD Card Schematic





FAT Filesystem

- Several Open Source AVR FAT on SPI SD Card implementations
 - WaveHC library for Arduino
 - Uzebox
 - FatFS and Petite FatFS (*pFatFS* - same author)
- ***SOLUTION***: Petite FatFS
 - Chosen for tiny size and simplicity
 - AVR SD Card example required hacking
 - bad timings



FAT FS Issues

- ***Issues with FAT FS on SD Card***

- Minimal RAM for caching (2kbyte MCU)
- Reading 1 byte requires reading full 512 byte sector from SD Card
- FAT random seek times LINEAR to seek position (VERY bad for 2 GB database).

- ***Solutions***

- Minimal 128 byte cache added
- Non-fragmented file seek optimization

•*USB Power*

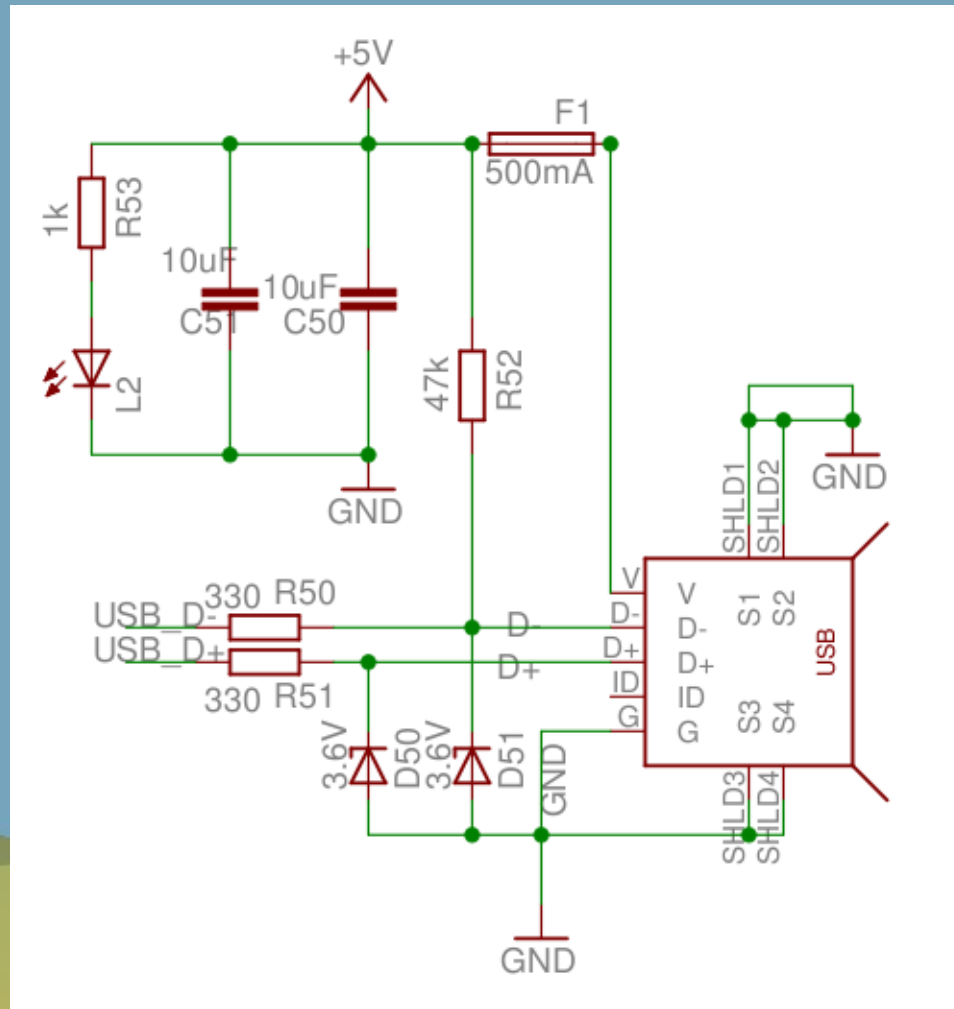
- Micro-USB 5V power connector
- Micro-USB new world-wide cell phone charger standard = low cost

•*USB Data Interface*

- Arduino uses a serial bootloader w/FT232 USB serial chip
- FT232** more **expensive**, less flexible than adding a third Atmega for USB peripherals
- Open **V-USB** project provides firmware

USB Schematic

- USB provides regulated **5V power**, but needs **3.3V data signaling**





Free or Open EDA Tools

- **Open Source GEDA Suite**

- (as of 2005, when I last used them)
- **gschem** - schematic capture - *"decent and usable"*
- **pcb** - layout - *"unsophisticated?"*

- **Cadsoft Eagle** (freeware/commercial)

- Unixy-feel - scriptable, cmd line, mostly parsable text file formats
- Free for simpler layouts
- *"Professional grade!"*

- **PCB Artist**

- freeware, Advanced Circuits
- new, simple, but Advanced lock-in





PCB Fabrication

- ***Advanced Circuits***

- Leader by far for fast-turn PCB fab
- Made in USA, great capabilities
- *"What I use for prototypes"*

- ***BatchPCB.com***

- super low cost
- batch together low volume panels of individual orders for fab in China
- long lead time

Home PCB Assembly

- Prototypes assembled myself

Tools for SMT home assembly

- Liquid flux w/needle dispenser bottle
- PCB cleaning alcohol and swabs
- Fine tip soldering iron
- desolder braid, etc
- GOOD tweezers
- Magnifier (Microscope)
- Hot air rework station
- Solder paste (optional)
- Good PCB vice



Suppliers



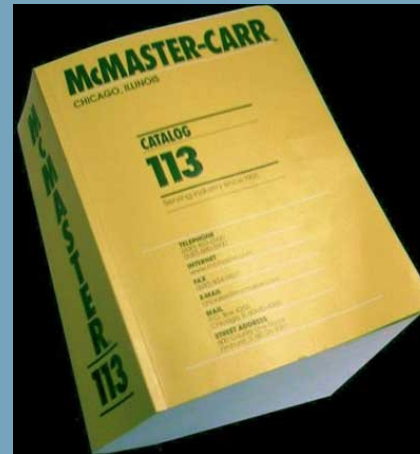
#1 in Quickturn PROTO & PRODUCTION PCBs



eMachineShop.com
machine custom parts online



a tti company



DuVac Electronics

1759 E. Colorado Blvd. Pasadena, CA 91106

Phone: 626-796-3291 Fax: 626-796-3292



.com



Enclosure

- **#1 - No Enclosure**
 - Hobbies require no enclosure
- **#2 - Conformal Coating/Paint**
 - *Conformal Coating* - an acrylic gloss used to protect PCBs
- **#3 - Plate/Spacer Sandwich**
 - Cost effective <1KU
- **#4 - Plastic Case**
 - Tooling Cost
 - Cost effective >1KU



PCB Assembly

- **Screaming Circuits**

- Leader in USA
- *Asmbly*: 100U = **\$27** per board!

- **EzPCB**

- China
- Set up for easy small runs
- *Asmbly*:
 - 100U = **\$9** per board
 - 1000U = **\$6** per board
 - 10kU = **\$4.50** per board

The BOM Stops Here

- Manufacturer should cost optimize your Bill of Materials in quotation.



Production Cost

Tvikia Reader Production Costs			
	100 U	1000 U	10k U
Parts (3)	\$12.37	\$ 9.27	\$ 8.60
PCB Fab (1)	\$ 2.15	\$ 0.95	\$ 0.51
Assembly (1)	\$ 9.00	\$ 6.00	\$ 4.50
Shipping (4)	\$ 1.20	\$ 0.75	\$ 0.50(2)
Coating (5)	\$ 0.25	\$ 0.25	\$ 0.25
TOTAL	\$24.97	\$17.21	\$14.36
(1) EzPCB Quote BASED ON PC DESIGN - add \$138 setup			
(2) Guestimate. Cheaper and slower shipping is available.			
(3) See BOM for part cost details - No SD Card			
(4) Shipping from Chinese Manufacturer			
(5) Conformal Coating, \$50/m ² (ezpcb)			

****Does not include enclosure or SD Card***



Fin

Braddock Gaskill

braddock@braddock.com

Humane Informatics

<http://humaneinfo.com>

humaneinfo.com

