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

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SGVLUG

Overview

-Present Device
-Overview
-Goals
-Device Demo
-Functional Requirements
-AVR Open Ecosystem - Uzebox
-AVR Open Ecosystem - Arduino
-AVR Open Ecosystem - gcc, avr-libc, avrdude
-AVR Open Ecosystem - avrfreaks, uzebox forums, etc
-Video Requirement - Tellymate
-SD Card Requirement - Wave Shield/Uzebox
-FAT Requirement - Petite FatFS
-USB Desirement - V-USB
-Schematic (Eagle, GEDA, gschem, PCB Artist)
-Layout
-Bill of Materials
-PCB Fabrication
-Assembly
-Pricing

Talk Overview

Today's Audience
- ~~Independently Wealthy Philanphrapists~~
- ~~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
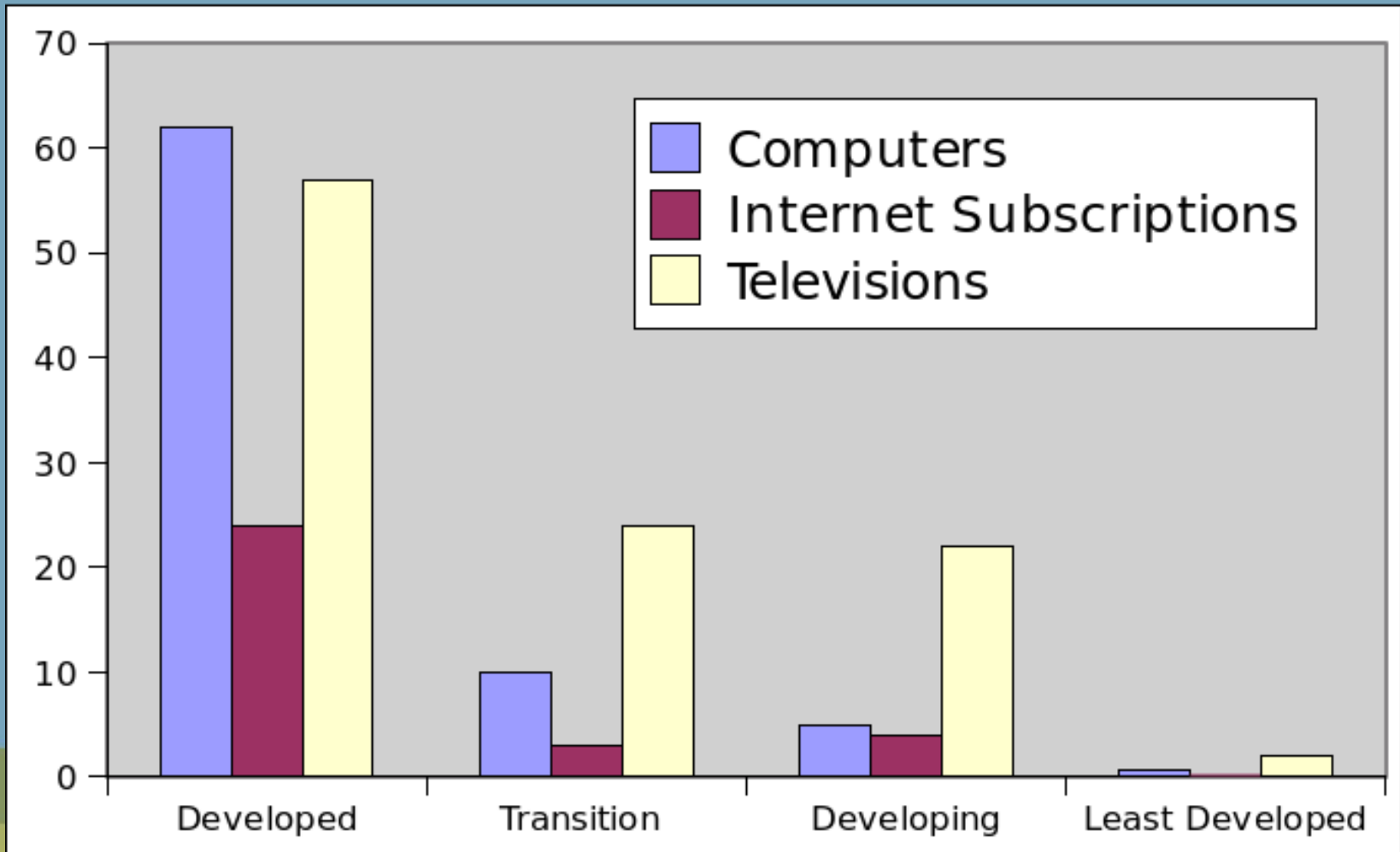- Survey of AVR Open Source **Hardware**
- Survey of AVR Open Source **Tools**
- Walk through of **design and design tools**
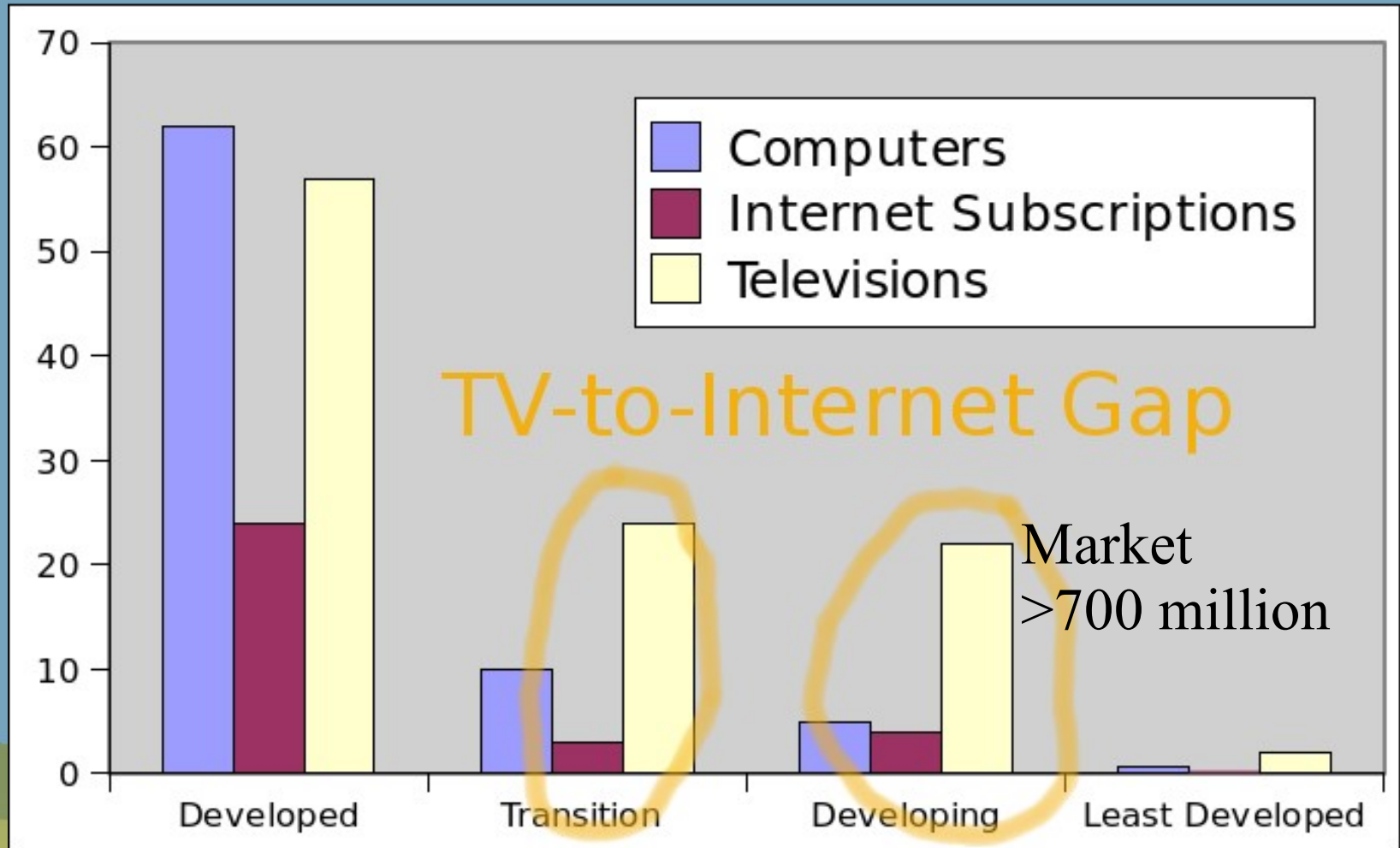- Walk through of **fabrication** and **manufacturing**

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

TV-to-Internet Gap

Market >700 million

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

*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)

SGVLUG

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

Design Requirements

NTSC/PAL Video Output

SD Card Interface (w/FAT)

Cheap Input Interface (buttons)
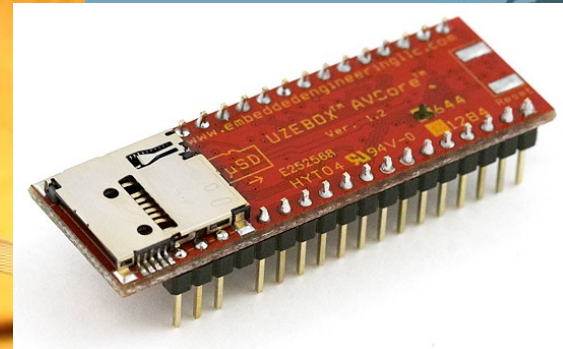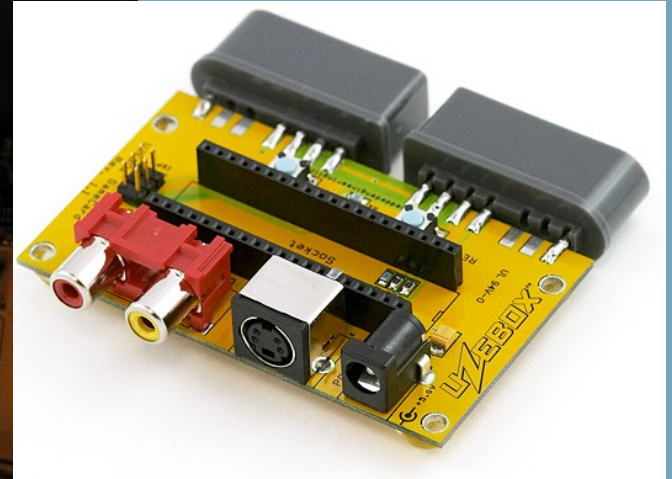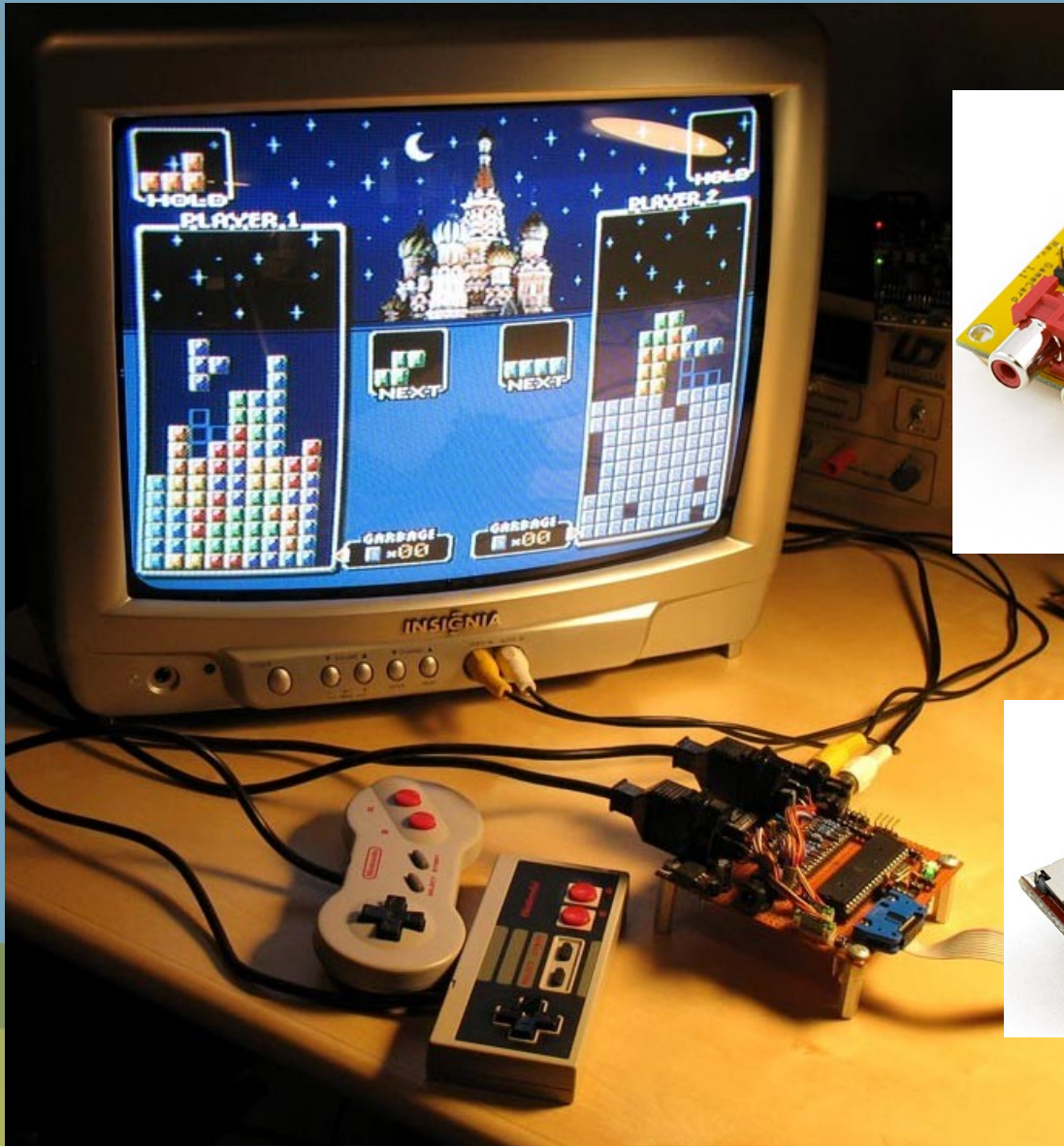
Power (Micro-USB Adaptor)

PS/2 Keyboard Interface (optional)

USB interface (optional)

Audio (optional)

IR (optional)

AVR Open Ecosystem: Uzebox

8 April 2010

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
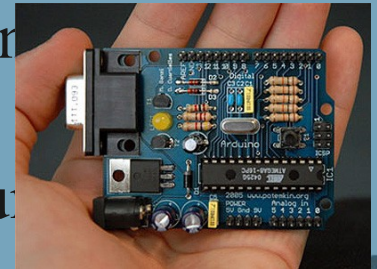
Too Expensive ($95 sparkfun)

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-orien "easy" IDE.

COMMUNITY: Excellent. Dev tutorials, foru

CONCLUSION: Shield, IDE, and software compatible.

AVR Open Ecosystem: Tools
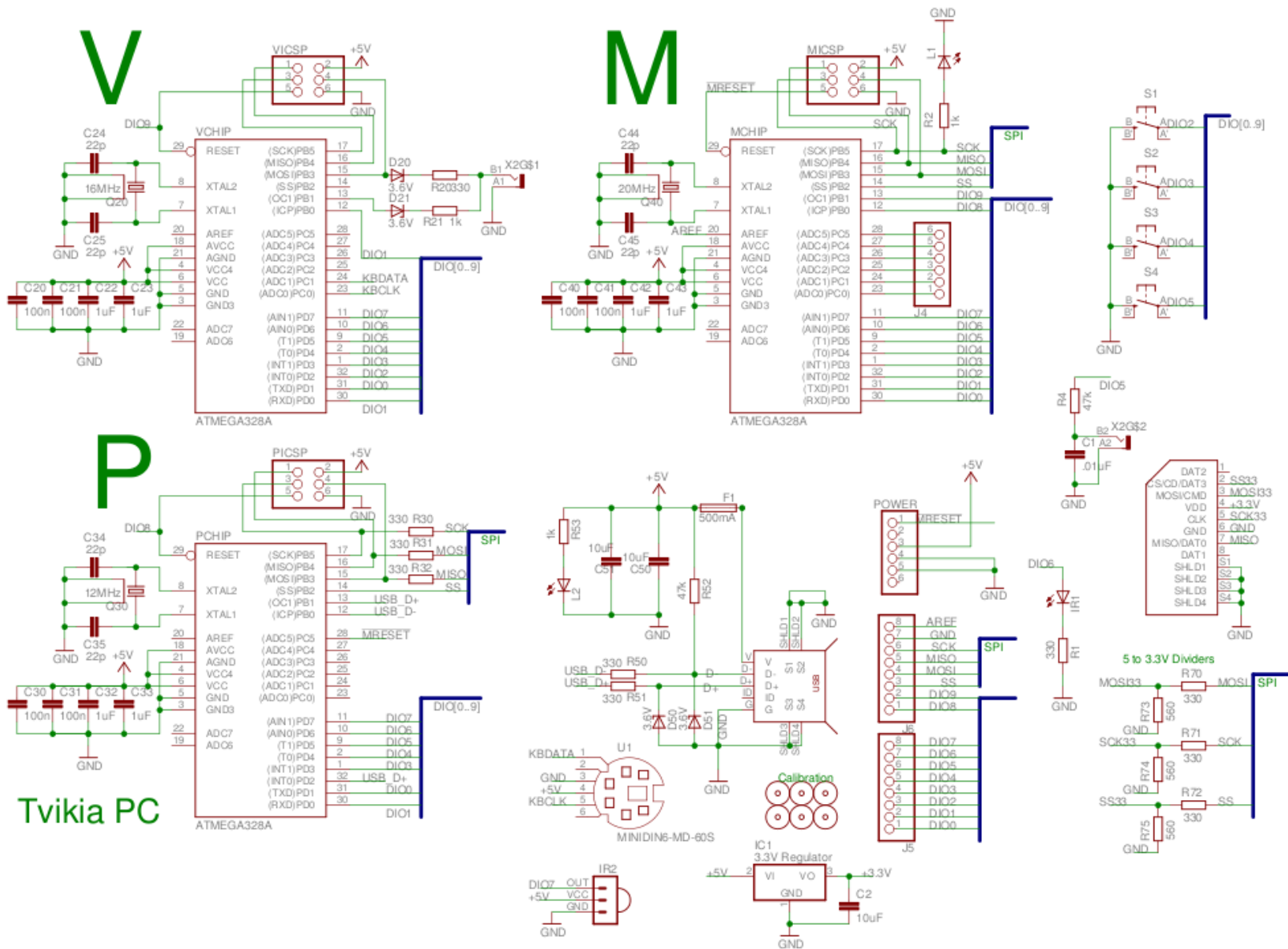
avr-gcc compiler - full C, partial C++, bintools, well supported alternative to Atmel's compiler

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.
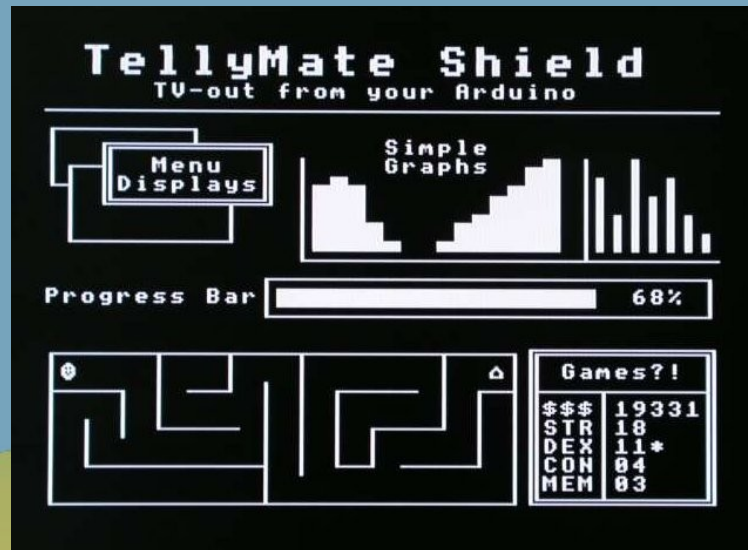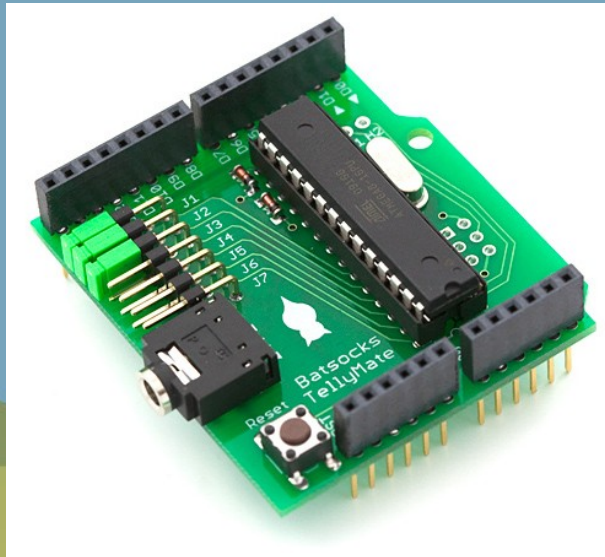
V

VICSP +5V
GND

DIO9

VCHIP
ATMEGA328A

RESET 29
XTAL2 8
XTAL1 7
AREF 20
AVCC 18
AGND 21
VCC4 4
VCC 6
GND 5
GND3 3
ADC7 22
AD06 19

(SCK)PB5 17
(MISO)PB4 16
(MOS)PB3 15
(SS)PB2 14
(OC1)PB1 13
(ICP)PB0 12
(ADC5)PC5 28
(ADC4)PC4 27
(ADC3)PC3 26
(ADC2)PC2 25
(ADC1)PC1 24
(ADC0)PC0 23
(AIN1)PD7 11
(AIN0)PD6 10
(T1)PD5 9
(T0)PD4 2
(INT1)PD3 1
(INT0)PD2 32
(TXD)PD1 31
(RXD)PD0 30

C24 22p
16MHz Q20
C25 22p
GND +5V
C20 100n C21 100n C22 1uF C23 1uF
GND

D20 3.6V D21 3.6V
R20 330 R21 1k
B1 X2G$1 A1
GND

DIO1
DIO[0..9]
KBDATA
KBCLK
DIO7
DIO6
DIO5
DIO4
DIO3
DIO2
DIO0
DIO1

M

MICSP +5V
MRESET
MCHIP
MCHIP
ATMEGA328A

L1
R2 1k
GND

SCK
MISO
MOSI
SS
DIO9
DIO8 DIO[0..9]

SPI

C44 22p
20MHz Q40
C45 22p
GND +5V
C40 100n C41 100n C42 1uF C43 1uF
GND

J4

DIO7
DIO6
DIO5
DIO4
DIO3
DIO1
DIO0

S1 ADIO2 DIO[0..9]
S2 ADIO3
S3 ADIO4
S4 ADIO5
GND

R4 47k DIO5
B2 X2G$2 A2
C1 .01uF
GND

DIO6 IR1

R1 330
GND

P

PICSP +5V
GND

DIO8

PCHIP
ATMEGA328A

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XTAL2 8
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AREF 20
AVCC 18
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(SCK)PB5 17
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(AIN1)PD7 11
(AIN0)PD6 10
(T1)PD5 9
(T0)PD4 2
(INT1)PD3 1
(INT0)PD2 32
(TXD)PD1 31
(RXD)PD0 30

C34 22p
12MHz Q30
C35 22p
GND +5V
C30 100n C31 100n C32 1uF C33 1uF
GND

R30 330 SCK
R31 330 MOSI
R32 330 MISO
SS
USB_D+
USB_D-

SPI

MRESET

DIO[0..9]

DIO7
DIO6
DIO5
DIO4
DIO3
USB_D+
DIO0
DIO1

Tvikia PC

DAT2
CS/CD/DAT3 SS33
MOSI/CMD MOSI33
VDD +3.3V
CLK SCK33
GND GND
MISO/DAT0 MISO
DAT1
SHLD1 S1
SHLD2 S2
SHLD3 S3
SHLD4 S4
GND

5 to 3.3V Dividers
R70 330 MOSI33 MOSI SPI
R73 560
SCK33 R71 330 SCK
R74 560
SS33 R72 330 SS
R75 560
GND

+5V
F1 500mA
R53 1k
C51 10uF C50 10uF
L2
GND

POWER MRESET
GND

47k R52
SHLD1 SHLD2 GND

USB_D- R50 330 D
USB_D+ R51 330 D+
D50 3.6V D51 3.6V
V D- D+ ID G usb
S1 S2 S3 S4
SHLD3 SHLD4

KBDATA U1
GND
+5V
KBCLK
MINIDIN6-MD-60S

Calibration

AREF
GND
SCK
MISO
MOSI
SS
DIO9
DIO8

SPI

J6
DIO7
DIO6
DIO5
DIO4
DIO3
DIO2
DIO1
DIO0
J5

DIO7 OUT
+5V VCC IR2
GND
GND

IC1 3.3V Regulator
+5V VI VO +3.3V
GND C2 10uF
GND

REQ: NTSC/PAL Video Output

PROBLEM: Very fast signal. For B&W, only a few cycles per dot.
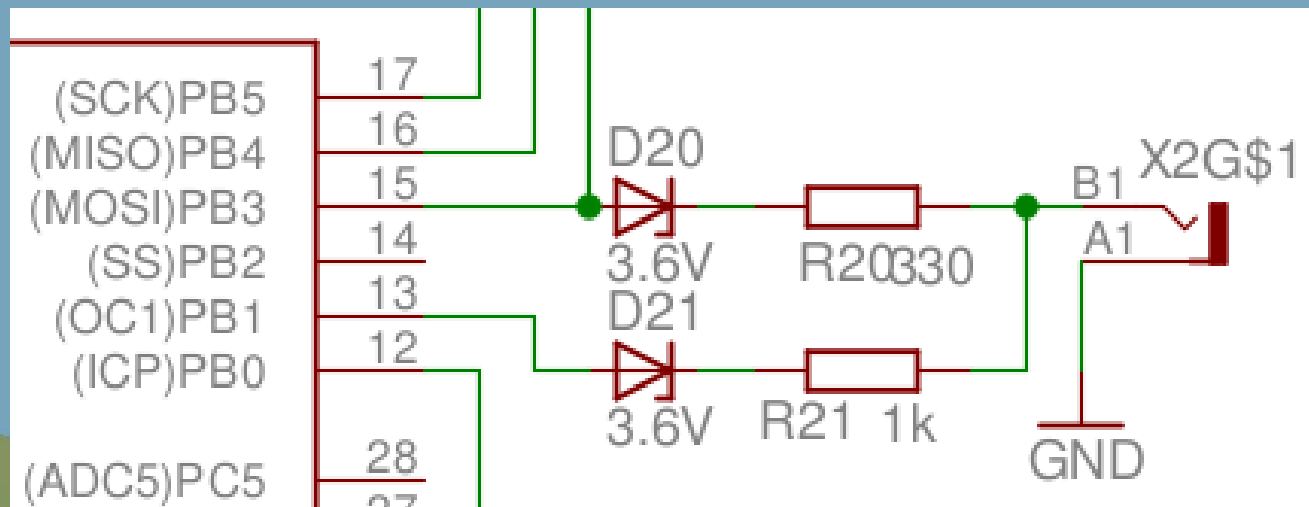
SOLUTION: Use existing **Tellymate** project software.

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

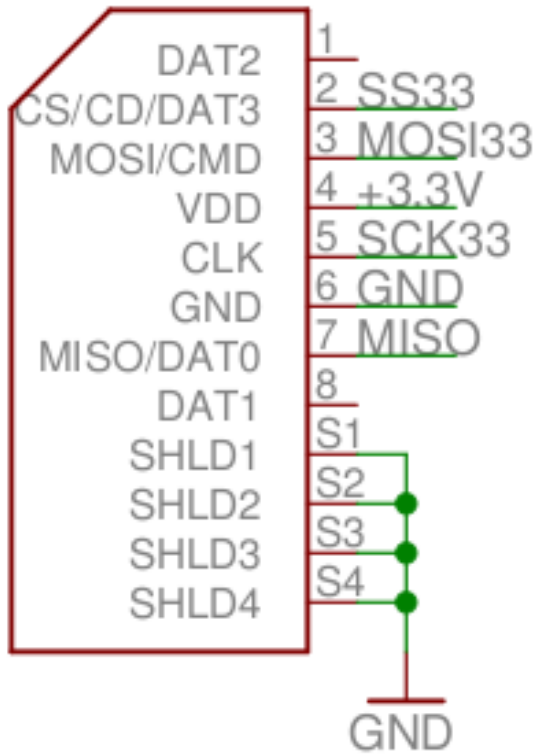**SOLUTION:** 5V to 3.3V voltage dividers for MCU output, MCU can discern 3.3V input

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
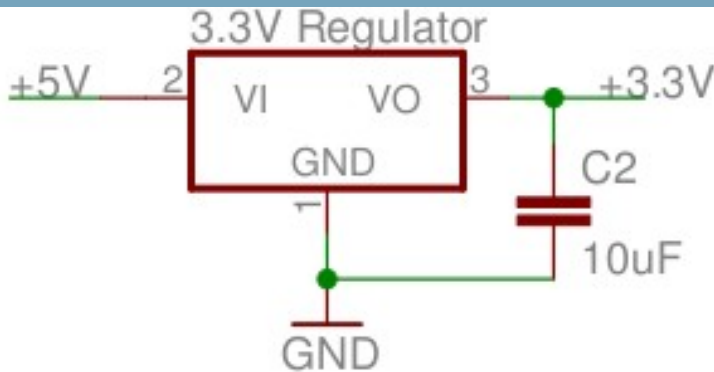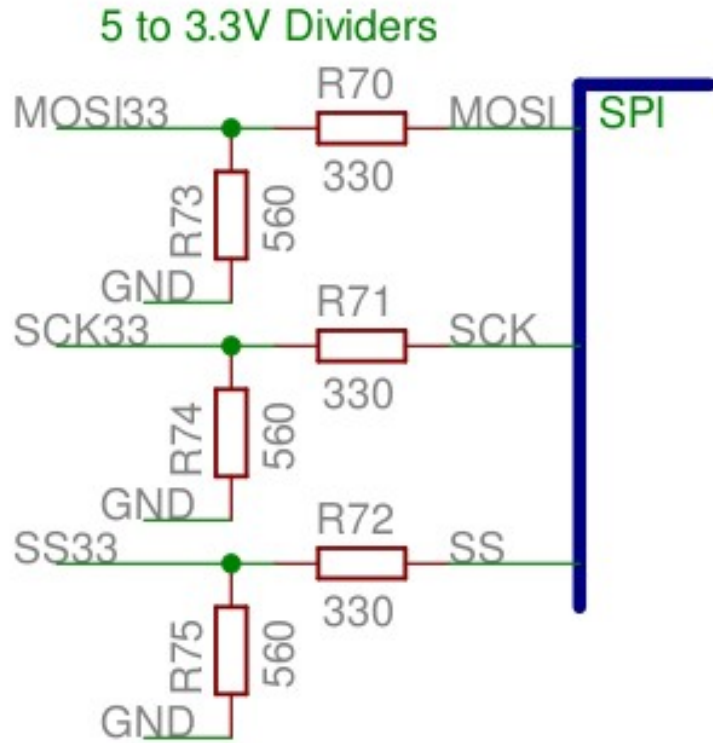
Several Open Source AVR FAT on SPI SD Card implementations

    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

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
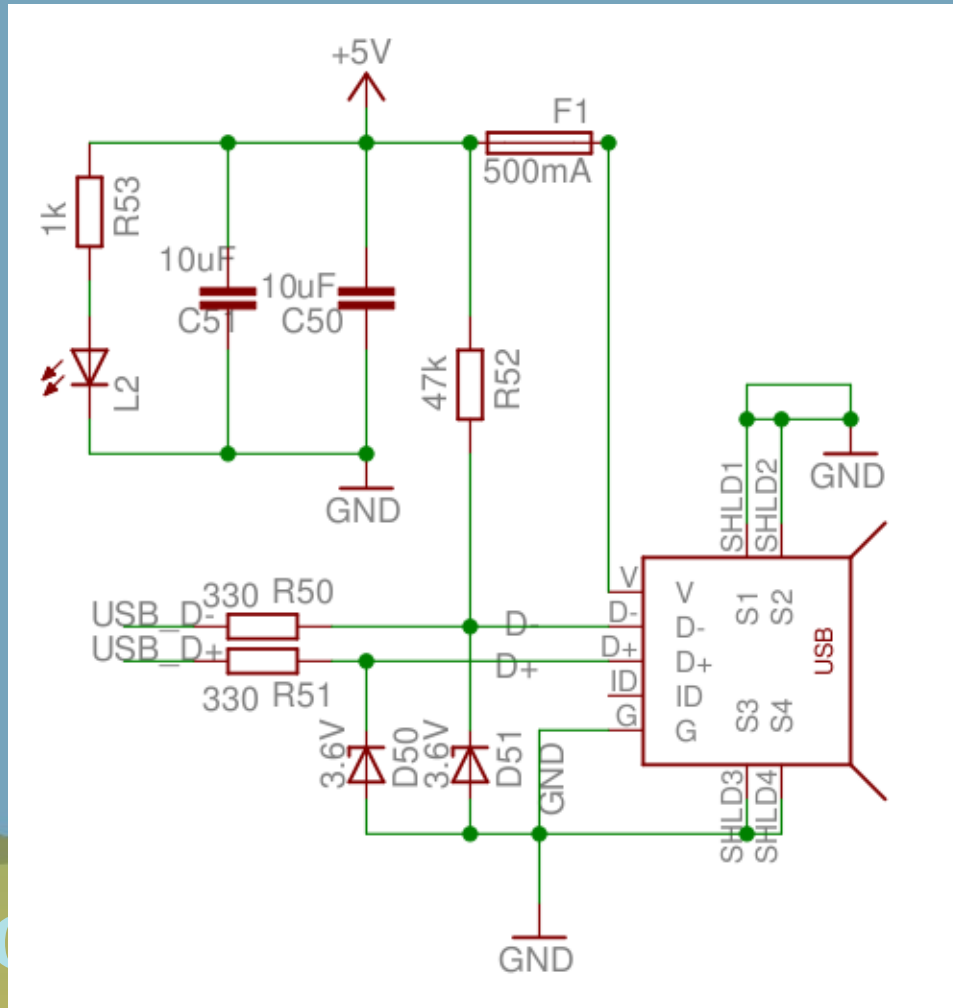
USB Data Interface

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 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
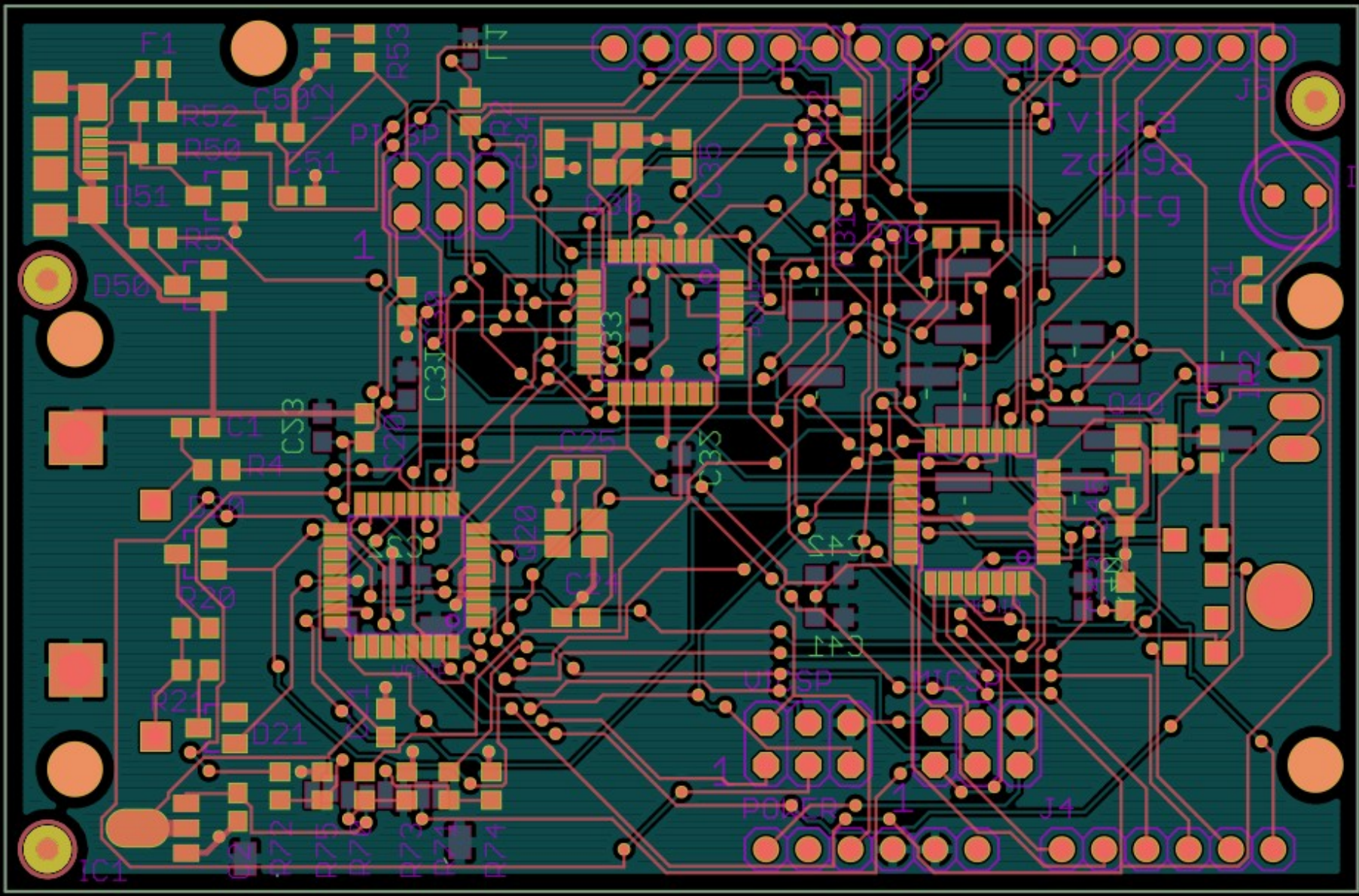
Free for simpler layouts

"Professional grade!"

PCB Artist

freeware, Advanced Circuits

new, simple, but Advanced lock-in

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)

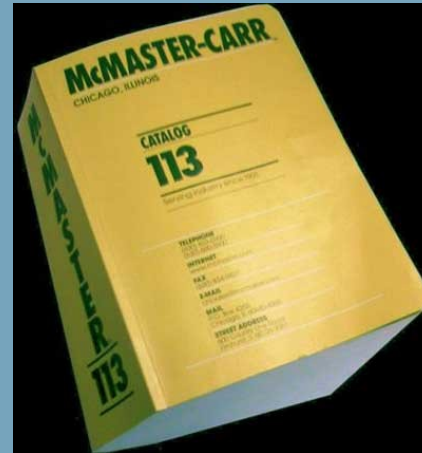Hot air rework station

Solder paste (optional)

Good PCB vice

SGVLU

Suppliers

ADVANCED CIRCUITS
#1 in Quickturn PROTO & PRODUCTION PCBs

Digi-Key CORPORATION

Edmund optics | america

eMachineShop.com
machine custom parts online

MOUSER ELECTRONICS
a tti company

sparkfun ELECTRONICS

McMASTER-CARR
CHICAGO, ILLINOIS
CATALOG
113

Newark

DuVac Electronics
1759 E. Colorado Blvd. Pasadena, CA 91106
Phone: 626-796-3291   Fax: 626-796-3292

April 2010

#1 - **No Enclosure**

Hobbiests 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

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.

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 SDCard

(4) Shipping from Chinese Manufacturer

(5) Conformal Coating, $50/m^2 (ezpcb)

*Does not include enclosure or SD Card