Speed Training
PCB Design for Software Engineers

Matt Liberty

President
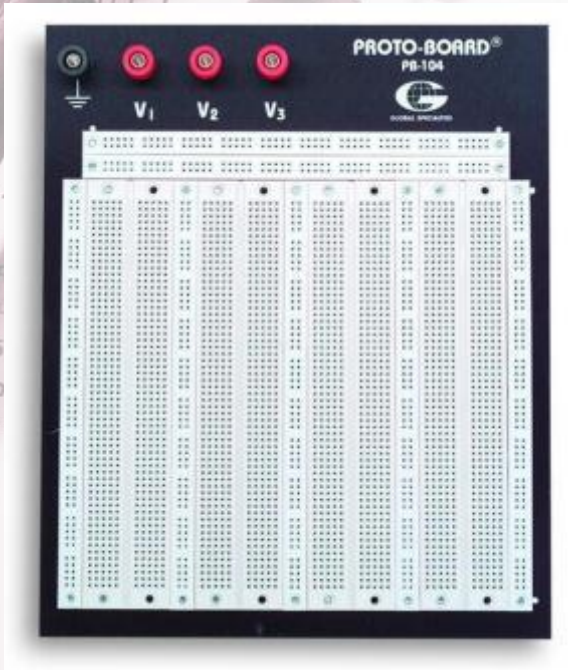
Jetperch LLC

www.jetperch.com

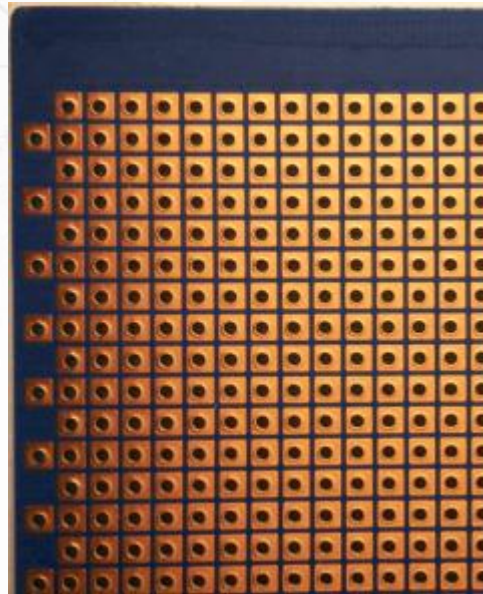↗ **Time to market and the development window are decreasing**

  ↗ Want reliable prototype hardware early in the development cycle

  ↗ Want to replicate the development platform across a team

  ↗ Asked to do more with less

↗ **Common solution**

  ↗ Combine development boards and reference platforms to emulate final product

  ↗ But how? How to do better?

Breadboard

Perfboard

Printed Circuit Board

http://commons.wikimedia.org/wiki/File:CopperCladPerfboard_1.png

UBM
Electronics

↗ **Provides mechanical connections to form a single physical unit**

  ↗ Hold components together

  ↗ Mounting holes & features integrate into the larger product

↗ **Provides electrical connections between components**

  ↗ Wires between components

  ↗ Multiple layers to allow wires to cross

  ↗ Vias (holes) to connect wires across layers

UBM Electronics

- **Features & requirements**

- **Component selection**

- **Schematics**
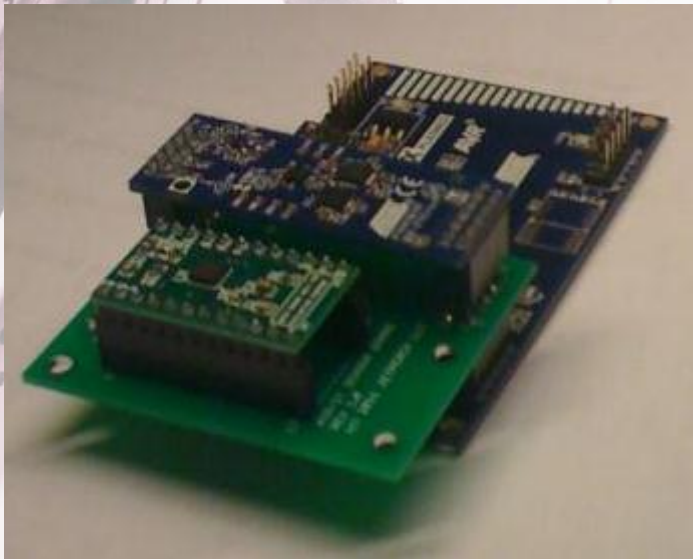 - A complete, definitive graphical description for how all components are logically connected

- **Layout**
  - A complete, definitive graphical description for how all components are physically connected

- **Fabricate Printed Circuit Board (PCB)**

- **Assemble Printed Circuit Assembly (PCA)**

- **Test**

↗ **Objective:** Develop drivers and evaluate the performance of a new sensor

↗ **2x5 interface connector (x2)**

  ↗ UC3-A3 Xplained board from Atmel

  ↗ ATAVRSBIN1 (for accelerometer)

↗ **3-axis XYZ gyroscope**

  ↗ STEVAL-MKI107V1 for L3G4200D from STMicroelectronics

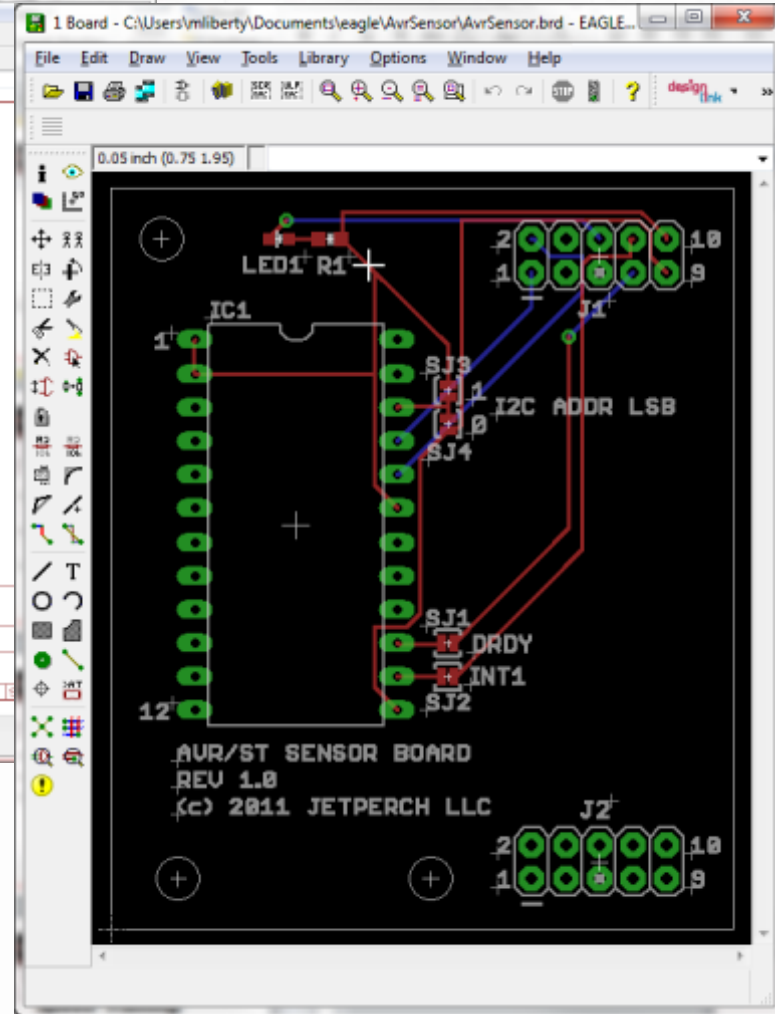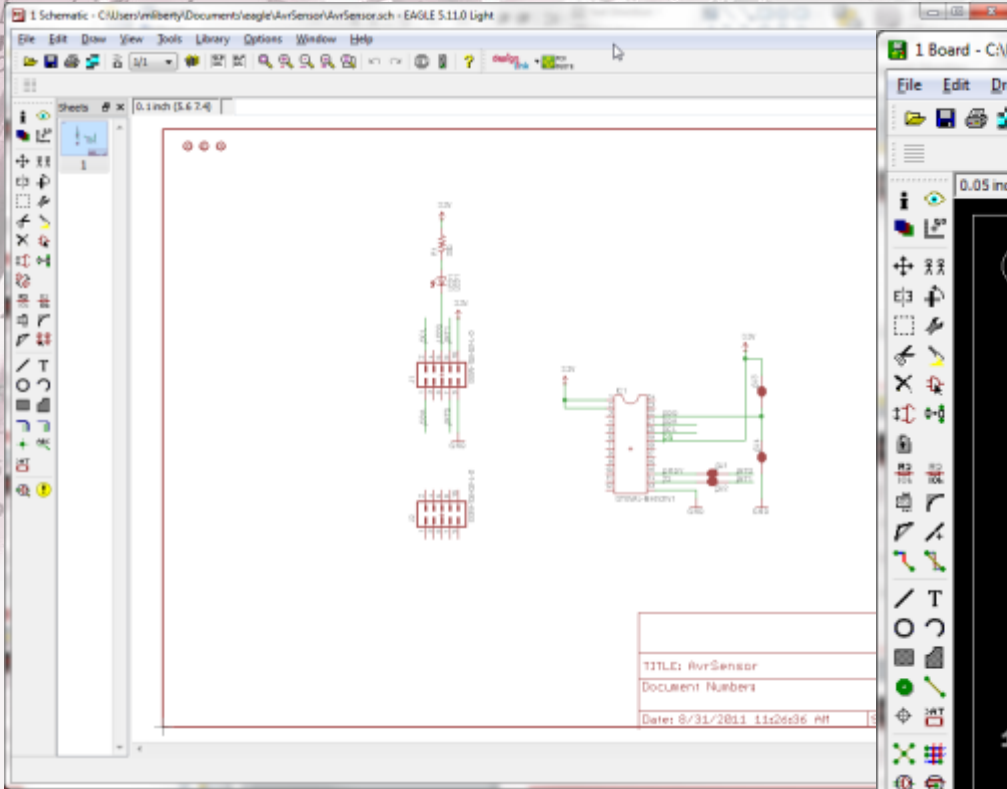 ↗ Configurable I^2C address

↗ **LED**

↗ **Eagle PCB**

  ↗ Schematic capture

  ↗ PCB Layout

  ↗ CAM Generator

  ↗ Sparkfun Eagle library

↗ **ViewPlot (Gerber Viewer)**

↗ **Online DRC**

  ↗ BatchPCB, Advanced Circuits

↗ **Be aware of grid (ALT key) and layers**

↗ **Provide options: solder jumpers & vias**

↗ **Double check footprints for all components**

↗ **Have someone else review the schematics and layout**

↗ **Check your Gerbers with a separate gerber viewer (Drill file is 2-4)**

↗ **When soldering, keep tip clean and use plenty of flux**

↗ **Slow edge rates on interconnects**

   ↗ Low-speed signals (< 25 MHz)

   ↗ I^2C, SPI, UART, full-speed USB

↗ **Few components and low signal density**

   ↗ Size is not critical

↗ **No analog or < 10 bit resolution**

↗ **Simple components only**

   ↗ No BGAs

   ↗ No fine-pitch parts

DesignDays
BOSTON

UBM
Electronics

↗ **Download this presentation from jetperch.com**

↗ **Explore reference resources**

↗ **Download & install tools**

↗ **Design your own PCB**
  ↗ Allocate 15 to 30 hours for first PCB
  ↗ Tools & supplies: $200
  ↗ PCB: $100 - $200 (1-week) or $20 (4-week)
  ↗ Components: $50 but varies by design

Alternative: Discuss this rapid, low-cost PCB process with your hardware engineers

Speed Training

PCB Design for Software Engineers

Matt Liberty
President
Jetperch LLC
www.jetperch.com

UBM
Electronics

Creating a printed circuit board (PCB) has become faster, cheaper and easier over the last several years, and software engineers can now add PCB design to their toolbox to create more reliable and repeatable development hardware. This session walks through the full design process for a 2-layer interconnect PCB using EaglePCB, a freely available schematic capture and layout tool. This session includes additional self-study references to demystify the tools, terminology and processes behind PCB design and assembly.

DesignDays
BOSTON

UBM
Electronics

Option	Advantages	Disadvantages
Wires (soldered or with clips)	• Fastest to create	• Mechanically and electrically unreliable • Cannot easily add components
Breadboard	• Fast to create	• Reliability depends upon craftsmanship • Time-consuming to replicate
Perfboard	• Fast to create	• Reliability depends upon craftsmanship • Time-consuming to replicate
Printed Circuit Board (PCB)	• Easy to replicate • Mechanically & electrically reliable • Easy to add resistors, LEDs & components	• Slower to create • Requires more planning • Requires process and tools knowledge

↗ **Fabrication (fab) drawing**

↗ **Board outline & routing**

    ↗ PCB layer stack-up

    ↗ Manufacturing process and options

↗ **Layers**

    ↗ Metal (top, bottom & inner layers)   [**GTL**, **GBL**]

    ↗ Solder mask (top, bottom)   [**GTS**, **GBS**]

    ↗ Solder paste (top, bottom)   [GTP, GBP] Used for printed circuit assembly

    ↗ Silk screen (top, bottom)   [**GTO**, GBO]

↗ **Drill**

    ↗ Drawing

    ↗ Drill size file   [**TXT**]

↗ **Panelization**

    ↗ Group PCBs into assembly panels (roughly 12" x 12")

    ↗ Group assembly panels into fabrication panels (roughly 2' x 3')

↗ **Assembly drawing**

Only items in red are required for low-volume prototyping

UBM Electronics

↗ [ITP Physical Computing Eagle PCB Tutorial](#)

↗ [PCB Design Tutorial](#) (PDF)

↗ [Eagle PCB Guided Tour](#) - Cadsoft

↗ [Eagle Schematic Tutorial](#) - Sparkfun

↗ [Eagle Layout Tutorial](#) - Sparkfun

↗ [Villanova Electronics Inventors Club PCB Tutorial](#)

↗ [How to Build a PCB](#) – Advanced Circuits

UBM Electronics

↗ **Prototype PCB Fab Houses**

   ↗ Advanced PCB – Quickturn prototype PCBs

   ↗ BatchPCB – Slow, inexpensive prototype PCBs

↗ **Prototype Assembly Houses**

   ↗ Advanced Assembly

   ↗ Screaming Circuits

↗ **Self-Assembly**

   ↗ Soldering Iron: Weller WESD51 ($129)

   ↗ Supplies ($50)

UBM
Electronics

↗ **How to Solder Video** – Curious Inventor

↗ **Soldering Tutorial Guide** – Principia Labs

↗ **Soldering Basics** – Sparkfun

↗ **Surface Mount Soldering** – Sparkfun

↗ **Soldering 101** – Indium

Recommendation: Learn using tin/lead solder, not lead-free.

Item	Manufacturer	Part #
Soldering iron	Weller	WESD51
Soldering iron fine tip	Weller	578-ETS
Solder (0.032" 22 gauge)	MG Chemicals	4890-18G
Solder (0.02")	Chip Quik	SMDSW.020 2oz
Soldering iron tip cleaning wire sponge	CML Supply	Amazon
Flux pen	MG Chemicals	835-P
Flux solvent	N/A	Isopropyl alcohol
Desoldering wick	MG Chemicals	425-NS
Calipers	Neiko	01407A

Small volume, prototyping & hobbyist

- ↗ Digikey – The leader for professional prototyping & small volume
- ↗ Mouser – Easier to navigate than Digikey, but less selection
- ↗ Samtec (connectors)
- ↗ iFixIt – do it yourself electronics repair parts
- ↗ Sparkfun – Hobby market
- ↗ SmallParts
- ↗ Radio Shack – Yes, they still sell electronic components
- ↗ Jameco

Mass production

- ↗ Avnet – The global leader in electronic component distribution
- ↗ Arrow Electronics
- ↗ Future Electronics
- ↗ Newark
- ↗ McMaster-Carr – Mechanical parts, fast

↗ **Sparkfun**

   ↗ Almost all designs have accompanying Eagle schematic and layout

   ↗ You could design <u>this UART to USB converter</u>

↗ **Cadsoft: <u>User Projects</u>**

↗ **<u>Eagle PCB</u>**

   ↗ $49 2 signal layers 100x80 mm area

   ↗ $747 6 signal layers 160x100 mm area

   ↗ $1404 16 signal layers 1600x1600 mm area

↗ **<u>Altium Designer</u> ($5000)**

↗ **Mentor Graphics (PADS)**

↗ **Cadence**

   ↗ Allegro

   ↗ OrCAD