Electronic circuit design and component selection

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MIT Media Lab
MAS.S63: Design for DIY Manufacturing
Goal for today’s lecture

• How to pick up components for your project
• Rule of thumb for PCB design
• Suggestions for PCB layout and manufacturing
• Soldering and de-soldering basics
• Small - medium quantity electronics project production

• Homework :
  Design a **PCB** for your project with a **BOM** (bill of materials) and estimate the **cost** for making 10 | 50 | 100 (PCB manufacturing + assembly + components)
Design Process

- Test Circuit
- Component Selection
- PCB Design
- Component Placement
- PCB Manufacturing
Design Process

- Test Circuit
- Module Selection
- PCB Design

- Component Placement
- PCB Manufacturing
Design Process

- **Test circuit** – bread boarding/ buy development tools (breakout boards) / simulation
- **Component Selection** – spec / size / availability (inventory! Need 10% more parts for pick and place machine)
- **PCB Design** – power/ground, signal traces, trace width, test points / extra via, pads / mount holes, big before small
- **PCB Manufacturing** – price-time trade-off/
- **Place Components** – first step (check power/ground) -- work flow
Test Circuit Construction

Breadboard + through hole components + Breakout boards, surfboards + hookup wires


Dual in-line (DIP) packaging

Breakout boards

Surfboard: surface-mount to through hole

http://www.beldynsys.com/cc521.htm
Development Boards
– good reference for circuit design and component selection

Sometimes, it can be cheaper to pair your design with a development board for your “product” if you are only manufacturing in a small quantity.
Simulate you (analog) circuit if needed!

Circuit Construction Kit (DC Only)

An electronics kit in your computer! Build circuits with resistors, light bulbs, batteries, and switches. Take measurements with the realistic ammeter and voltmeter. View the circuit as a schematic diagram, or switch to a life-like view.

Download 2.109 KB  Run Now!

Embed

Version: 3.20 (change log)

http://www.ecircuitcenter.com/
http://www.circuitlab.com/
http://phet.colorado.edu/en/simulation/
http://www.openmusiclabs.com/testpage/
http://www.daycounter.com/
...and more!
Design Process

- **Test circuit** – bread boarding/ buy development tools (breakout boards) / simulation
- **Component Selection** – spec / size / availability (inventory! Need 10% more parts for pick and place machine)
- **PCB Design** – power/ground, signal traces, trace width, test points / extra via, pads / mount holes, big before small
- **PCB Manufacturing** – price-time trade-off/
- **Place Components** – first step (check power/ground)
  -- work flow
Electronic Components Distributor

Components
**Wire Selection**

- **WIRE GAUGE — AWG** (American wire gauge)
  - the diameters of round, solid, nonferrous, electrically conducting wire. The cross-sectional area of each gauge is an important factor for determining its current-carrying capacity.

- **JACKET** (Insulation)
  - The jacket physically protects the internal components of a cable, improves the cable’s appearance and provides flame retardancy – Protects from the environment–Protects from the rigors of installation

Cabling

Solid

Stranded

Coax - BNC

Coax - SMA

Pre-crimped wire


Stranded wire is used when higher resistance to metal fatigue is required.

Flexible flat cable (FFC)

http://www.asiconnectors.com/member/x964-Flexible-Flat-Cable-Connectors.asp

Twisted Pair

two conductors (the forward and return conductors of a single circuit) are twisted together for the purposes of canceling out electromagnetic interference (EMI) from external sources

http://www.conductiveinkjet.com/

RG-59 CABLE
A: outer plastic sheath
B: woven copper shield
C: inner dielectric insulator
D: copper core

breadboard jumpers – 23 AWG
on-board jumpers > 30 AMG

www.conductiveinkjet.com/
- Antenna for Zigbee Radio: ¼ wavelength solid 23 AWG wire
- Jumpers between chips: 30 AWG solid wire
- Connector for flexible flat cable (for programmer)
Switches - mechanical or actuators

- **Accessories (4,049 items)**
- **Accessories - Caps (1,798 items)**
- **Configurable Switch Components - Body (783 items)**
- **Configurable Switch Components - Contact Block (199 items)**
- **Configurable Switch Components - Illumination Source (91 items)**
- **Configurable Switch Components - Lens (188 items)**
- **DIP (4,011 items)**
- **Keylock (609 items)**
- **Keypads (503 items)**
- **Magnetic, Reed (776 items)**
- **Navigation, Joystick (184 items)**
- **Programmable Display (18 items)**
- **PushButton (12,919 items)**
- **PushButton - Hall Effect (15 items)**
- **Rocker (4,502 items)**
- **Rotary (1,226 items)**
- **Selector (541 items)**
- **Slide (1,647 items)**
- **Snap Action, Limit, Lever (8,655 items)**
- **Tactile (4,462 items)**
- **Thumbwheel (336 items)**
- **Toggle (6,699 items)**

http://search.digikey.com/scripts/DkSearch/dksus.dll;x=0&y=0&lang=en&site=us&KeyWords=switch
# Switches

<table>
<thead>
<tr>
<th>Electronics specification</th>
<th>Expansion</th>
<th>Description</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SPST</strong></td>
<td>Single pole, single throw</td>
<td>A simple on-off switch: The two terminals are either connected together or disconnected from each other. An example is a light switch.</td>
<td>![Symbol]</td>
</tr>
<tr>
<td><strong>SPDT</strong></td>
<td>Single pole, double throw</td>
<td>A simple changeover switch: C (COM, Common) is connected to L1 or to L2.</td>
<td>![Symbol]</td>
</tr>
<tr>
<td><strong>SPCO</strong> or <strong>SPTT, c.o.</strong></td>
<td>Single pole changeover or Single pole, centre off or Single Pole, Triple Throw</td>
<td>Similar to SPDT. Some suppliers use SPCO/SPTT for switches with a stable off position in the centre and SPDT for those without. [citation needed]</td>
<td>![Symbol]</td>
</tr>
<tr>
<td><strong>DPST</strong></td>
<td>Double pole, single throw</td>
<td>Equivalent to two SPST switches controlled by a single mechanism</td>
<td>![Symbol]</td>
</tr>
<tr>
<td><strong>DPDT</strong></td>
<td>Double pole, double throw</td>
<td>Equivalent to two SPDT switches controlled by a single mechanism.</td>
<td>![Symbol]</td>
</tr>
<tr>
<td><strong>DPCO</strong></td>
<td>Double pole changeover or Double pole, centre off</td>
<td>Equivalent to DPDT. Some suppliers use DPCO for switches with a stable off position in the centre and DPDT for those without.</td>
<td>![Symbol]</td>
</tr>
</tbody>
</table>

## Battery

### Three basic things - **Cell Voltage**, **Load Current**, **Amp-Hour** (symbol Ah, AHR, A·h, A h)

<table>
<thead>
<tr>
<th>NiCad</th>
<th>NiMH</th>
<th>Lead Acid</th>
<th>Li-Ion</th>
<th>Li-Polymer</th>
<th>Rechargeable Alkaline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravimetric Energy Density (Wh/kg)</td>
<td>45 - 80</td>
<td>60 - 120</td>
<td>30 - 50</td>
<td>110 - 160</td>
<td>100 - 150</td>
</tr>
<tr>
<td>Internal Resistance (mΩ)</td>
<td>100 - 200</td>
<td>200 - 300</td>
<td>&lt;100</td>
<td>150 - 250</td>
<td>200 - 300</td>
</tr>
<tr>
<td>(includes peripheral circuits)</td>
<td>6V pack</td>
<td>6V pack</td>
<td>12V pack</td>
<td>7.2V pack</td>
<td>7.2V pack</td>
</tr>
<tr>
<td></td>
<td>6V pack</td>
<td>6V pack</td>
<td>12V pack</td>
<td>7.2V pack</td>
<td>6V pack</td>
</tr>
<tr>
<td>Cycle Life (to 80% of initial capacity)</td>
<td>1500</td>
<td>300 - 500</td>
<td>200 - 300</td>
<td>500 - 1000</td>
<td>300 - 500</td>
</tr>
<tr>
<td>Self-discharge / Month (room temp)</td>
<td>20%</td>
<td>30%</td>
<td>5%</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>1.25V</td>
<td>1.25V</td>
<td>2V</td>
<td>3.6V</td>
<td>3.6V</td>
</tr>
<tr>
<td></td>
<td>1.25V</td>
<td>1.25V</td>
<td>2V</td>
<td>3.6V</td>
<td>1.5V</td>
</tr>
<tr>
<td>Load Current*</td>
<td>20C</td>
<td>5C</td>
<td>5C</td>
<td>&gt;20C</td>
<td>&gt;20C</td>
</tr>
<tr>
<td>- peak</td>
<td>1C</td>
<td>0.5C or less</td>
<td>0.2C</td>
<td>5C or less</td>
<td>5C or less</td>
</tr>
<tr>
<td>- best result</td>
<td>&gt;20C</td>
<td>&gt;20C</td>
<td>&gt;20C</td>
<td>&gt;20C</td>
<td>&gt;20C</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40 - 60°C</td>
<td>-20 - 60°C</td>
<td>-20 - 60°C</td>
<td>-20 - 60°C</td>
<td>0 - 60°C</td>
</tr>
<tr>
<td>Maintenance Requirement</td>
<td>30 - 60 days</td>
<td>60 - 90 days</td>
<td>3 - 6 months</td>
<td>not req.</td>
<td>not req.</td>
</tr>
</tbody>
</table>

*http://www.rfcafe.com/references/electrical/batteries.htm*
Footprint - same component / IC comes in different footprints
Flat Chips - Capacitors and Resistors

How to read the value:

- **334** = $33 \times 10^4$ ohms = 330 kilohms
- **222** = $22 \times 10^2$ ohms = 2.2 kilohms
- **473** = $47 \times 10^3$ ohms = 47 kilohms
- **105** = $10 \times 10^5$ ohms = 1.0 meg ohm

http://www.topline.tv/SMDnomen.pdf
Capacitors

Voltage rating for capacitors –
Really important for power circuits


http://www.bcae1.com/capacitr.htm

Example:

A case =

<table>
<thead>
<tr>
<th>Length</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2 mm</td>
<td>1.6 mm</td>
</tr>
</tbody>
</table>

Footprint - same IC comes in different footprints

SMD (surface-mount device) ICs

http://www.topline.tv/SMDnomen.pdf

Courtesy of Analog Device’s poster
SOIC (Small Outline Integrated Circuit)

<table>
<thead>
<tr>
<th>DRAWING</th>
<th>NOMENCLATURE</th>
<th>BODY WIDTH</th>
<th>LEAD TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 - 16 PIN</td>
<td>SO = Small Outline</td>
<td>156 mil</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SOM = Medium Outline</td>
<td>220 mil</td>
<td>Gull 50 mil Pitch</td>
</tr>
<tr>
<td>16 - 32 PIN</td>
<td>SOL = &quot;Large&quot; Outline</td>
<td>300 mil</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SOP = &quot;Small&quot; Outline Package</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 - 40 PIN</td>
<td>SOJ or SOL-J = &quot;J&quot; - Lead Large Outline</td>
<td>300 mil*</td>
<td>J-Lead 50 mil</td>
</tr>
<tr>
<td></td>
<td>VSOP = Very Small Outline Package</td>
<td>300 mil</td>
<td>Gull Wing 25 mil</td>
</tr>
<tr>
<td>32 - 56 PIN</td>
<td>SSOP = Shrink Small Outline Package</td>
<td>208 mil</td>
<td>Gull Wing 25 mil</td>
</tr>
<tr>
<td></td>
<td>QSOP = Quarter Small Outline Package</td>
<td>156 mil</td>
<td>Gull Wing 25 mil</td>
</tr>
</tbody>
</table>

*Up to 440 mils

http://www.topline.tv/SMDnomen.pdf
PCB design software

Free software

EAGLE (Easily Applicable Graphical Layout Editor)  http://www.cadsoftusa.com/


Two major components
- Schematics
- PCB Layout

And sometimes.. 3D simulation

http://www.freepcb.com/
http://www.expresspcb.com/
http://www.4pcb.com/free-pcb-layout-software/

And more...

But it's just another CAD software
PCB design software

Things you need to know

1. Pick your software (we will have a tutorial on EAGLE)
2. Pick the parts → build “footprint” for the parts, or find them from a library
3. Draw circuit diagram → Schematics
4. Route the physical circuitry → PCB Layout
Things you need to know

1. Pick your software (we will have a tutorial on EAGLE)
2. Pick the parts → build “footprint” for the parts, or find them from a library
3. Draw circuit diagram → Schematics
4. Route the physical circuitry → PCB Layout

Design schematics with components from a library

Create PCB file from schematics
Things you need to know

1. Pick your software (we will have a tutorial on EAGLE)
2. Pick the parts → build “footprint” for the parts, or find them from a library
3. Draw circuit diagram → Schematics
4. Route the physical circuitry → PCB Layout

Tips - right click to switch through routing menu
middle click to switch between layers
PCB design rule of thumb

• **Trace width for signal and power lines**
  – When placing narrow traces, 0.012" or less, avoid sharp right angle turns, use 45 or 135 degree turns. The problem here is that in the board manufacturing process, the outside corner can be etched a little more narrow and causes transmission reflections.
  – Power trace width depending on the current

• **Noise reduction**
  – Decoupling capacitors
  – Analog/Digital trace placement

• **Via and mount holes**
  – Resistance and power drop of vias
  – Mount holes for better ground connections
  – Connectors for better debugging
  – Repurpose of your PCBs

• **Design iteration**
Trace width calculation – to avoid voltage drop (trace resistance) and over heating

**PCB Trace Width Calculator** January 31, 2006

This Javascript web calculator calculates the trace width for printed circuit boards based on a curve fit to IPC-2221 (formerly IPC-D-275). Also see the via calculator.

New features:
- Results update as you type
- Several choices of units
- Units and other settings are saved between sessions
- Blog format allows user comments

**Inputs:**

<table>
<thead>
<tr>
<th>Current</th>
<th>2</th>
<th>Amps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
<td>1</td>
<td>oz/ft^2</td>
</tr>
</tbody>
</table>

**Optional Inputs:**

| Temperature Rise | 10 | Deg C |
| Ambient Temperature | 25 | Deg C |
| Trace Length | 1 | inch |

**Results for Internal Layers:**

| Required Trace Width | 80.0 | mil |
| Resistance | 0.00631 | Ohms |
| Voltage Drop | 0.0126 | Volts |
| Power Loss | 0.0252 | Watts |

**Results for External Layers in Air:**

| Required Trace Width | 30.8 | mil |
| Resistance | 0.0164 | Ohms |
| Voltage Drop | 0.0328 | Volts |
| Power Loss | 0.0656 | Watts |

**Area[mils^2] = (I[Amps]/(k*(Temp_Rise[deg. C])^b))^(1/c)**

Then, the Width is calculated:

**Width[mils] = Area[mils^2]/(Thickness[oz]*1.378[mils/oz])**

[http://circuitcalculator.com/wordpress/2006/01/31/pcb-trace-width-calculator/]
This Javascript web calculator calculates the resistance, voltage drop, and power loss of printed circuit board vias. Note that vias are made out of plated copper which typically has a resistivity of 1.7E-6 to 2.2E-6 Ohm-cm. The calculator has an input box for the resistivity which defaults to 1.9E-6 Ohm-cm.

Updates:
May 22, 2006 – Added thermal resistance calculation.
June 21, 2007 – Added estimated ampacity. See comment 17.

Inputs:

<table>
<thead>
<tr>
<th>Finished Hole Dia</th>
<th>18</th>
<th>mil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plating Thickness</td>
<td>1</td>
<td>mil</td>
</tr>
<tr>
<td>Via Length</td>
<td>60</td>
<td>mil</td>
</tr>
</tbody>
</table>

Optional Inputs:

<table>
<thead>
<tr>
<th>Applied Current</th>
<th>1</th>
<th>Amps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plating Resistivity</td>
<td>1.9E-6</td>
<td>Ohm-cm</td>
</tr>
</tbody>
</table>

Electrical Results:

<table>
<thead>
<tr>
<th>Resistance</th>
<th>0.000752</th>
<th>Ohms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage Drop</td>
<td>0.000752</td>
<td>Volts</td>
</tr>
<tr>
<td>Power Loss</td>
<td>0.000752</td>
<td>Watts</td>
</tr>
<tr>
<td>Estimated Ampacity</td>
<td>2.56</td>
<td>Amps</td>
</tr>
</tbody>
</table>

Thermal Results:

<table>
<thead>
<tr>
<th>Thermal Resistance</th>
<th>98.5</th>
<th>Deg. C/Watt</th>
</tr>
</thead>
</table>
Fig. 15. Ground plane provides near ideal single point ground.

Constructing Your Power Supply-Layout Considerations
A **ferrite bead** is a passive electric component used to suppress high frequency noise in electronic circuits. It employs high dissipation of high frequency currents in a ferrite to build high frequency noise suppression devices.

http://en.wikipedia.org/wiki/Ferrite_bead
Decoupling

- Decoupling is the process of adding small LC networks to ICs to provide a low impedance to ground at high frequencies and surge current at switching frequencies.
- A big capacitor in parallel with a small capacitor
- Make sure the capacitors are placed right next to the power input
PCB layers

- The basic layers are: copper, silk screen, solder mask, and NC Drill.

Copper layer stands for the conductive wires, silk screen is the marks and names, solder mask (stop layer) is the top non-conductive layer, and NC drill is the drill hole location.

For example, if you need a two layer PCB with top layer silk screen, you will need to send:

- Top Copper (GTL)
- Top Solder mask (GTS)
- Top Silkscreen (GTO)
- Bottom Copper (GBL)
- Bottom Solder mask (GBS)
- Bottom Silkscreen (GBO)
- Drill File

Solder mask comes in different colors.
Don’t connect grounds with traces, use polygon pour
HOLD NOTICE / FreeDFM CHECK

View sample FreeDFM report below.

<table>
<thead>
<tr>
<th>Potential Show Stoppers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missing Soldermask Clearance (112 violations)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Problems Automatically Fixed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient SMT Soldermask Clearance (15 violations)</td>
</tr>
<tr>
<td>Insufficient Soldermask Clearance (466 violations)</td>
</tr>
<tr>
<td>Insufficient Silkscreen Line Width (515 violations)</td>
</tr>
</tbody>
</table>

Three zoom view of Insufficient SMT Soldermask Clearance.

Three zoom view of Insufficient Annual Ring.

* Based on time of order to time of shipment.
PCB Assembly

- Things you need to know
  - Soldering
  - De-soldering
  - Re-flow
  - Small to medium quantity manufacturing
    - Pick and Place Machine
    - Reflow oven
Soldering

http://www.youtube.com/watch?v=5uiroWBkdFY&feature=related
Soldering

- **Solder size**
  - Depending on the size of the part

- **Solder paste**
  - For SMD components

- **Solder tips**

http://store.curiousinventor.com/guides/Surface_Mount_Soldering/Tools/
De-soldering and Re-flow

- **Flux** - chemical cleaning agent, flowing agent, or purifying agent
- **Solder Sucker** or **Solder-wick**

**Hot air station**
for removing quad flat packages (where there are too many leads to properly de-solder it without)

**Infrared Rework Station**
Same idea with the hot air station,
The only difference is it won’t blow away tiny parts
PCB manufacturing and assembly

http://www.custompcb.com/
starting at $18 each
http://www.advancedcircuits.com/
$33/board (student)
http://www.streamlinecircuits.com/

Need to know
1. Board layers
2. Material (FR4)
3. Trace width
4. Solder mask and silkscreen color
5. Thickness
6. Panel?

<table>
<thead>
<tr>
<th>Width (inches)</th>
<th>Length (inches)</th>
<th>Quantity (minimum)</th>
<th>Size (square inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>3</td>
<td>100</td>
<td>9</td>
</tr>
</tbody>
</table>

### Calculate Costs

Prototype PCBs, no soldermask or silkscreen, usually 1-3 day turn.

<table>
<thead>
<tr>
<th>PCB Manufacturer</th>
<th># PCBs</th>
<th>Cost Per</th>
<th>Cost</th>
<th>Shipping</th>
<th>Total</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barebones PCB</td>
<td>100</td>
<td>6.47</td>
<td>647</td>
<td>20</td>
<td>667</td>
<td>Can deduct cost from future production orders</td>
</tr>
<tr>
<td>PCB express E1</td>
<td>109</td>
<td>7.15</td>
<td>715</td>
<td>Free</td>
<td>715</td>
<td>Prototype PCBs</td>
</tr>
</tbody>
</table>

AP(Circuit basic)

### Calculate Costs

Prototype PCBs, with 2 sides green mask and 1 or 2 sides silkscreen, usually 3-10 day turn.

<table>
<thead>
<tr>
<th>PCB Manufacturer</th>
<th># PCBs</th>
<th># Panels</th>
<th>PCBs per Panels</th>
<th>Cost Per</th>
<th>Cost</th>
<th>Shipping</th>
<th>Total</th>
<th>Lead Time</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sierra Boost</td>
<td>100</td>
<td>100</td>
<td>1</td>
<td>30</td>
<td>3000</td>
<td>20</td>
<td>3200</td>
<td>5 day</td>
<td>One design only, 3 pieces minimum</td>
</tr>
<tr>
<td>Sierra Boost</td>
<td>102</td>
<td>17</td>
<td>6</td>
<td>54660008</td>
<td>5120</td>
<td>10</td>
<td>5220</td>
<td>5 day</td>
<td>Will not depanel, 3 piece minimum</td>
</tr>
<tr>
<td>PCB express E2</td>
<td>100</td>
<td>100</td>
<td>1</td>
<td>23.84</td>
<td>2384</td>
<td>Free</td>
<td>2384</td>
<td>2 day</td>
<td>Prototype PCBs</td>
</tr>
<tr>
<td>Cal Fox 100 sq. in.</td>
<td>110</td>
<td>10</td>
<td>11</td>
<td>19500000</td>
<td>1900</td>
<td>Free</td>
<td>1900</td>
<td>Up to 6 day</td>
<td>Free depanelization, but $190 for multi-project, ships FedEx from China. Often has 10% discount</td>
</tr>
<tr>
<td>Cal Fox 155 sq. in.</td>
<td>102</td>
<td>8</td>
<td>17</td>
<td>14700002</td>
<td>1400</td>
<td>Free</td>
<td>1400</td>
<td>Up to 6 day</td>
<td>Free depanelization, but $190 for multi-project, ships FedEx from China. Often has 10% discount</td>
</tr>
<tr>
<td>Olimex DS2</td>
<td>102</td>
<td>51</td>
<td>2</td>
<td>165</td>
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Cheap way to test your circuit design – barebones PCB without solder mask

Cheap way to get more boards made from the same order

Put via everywhere so you can separate different designs!

Break the board with a bender
Board assembly

- http://www.protoexpress.com/
- http://www.advancedcircuits.com/
- http://www.spinpcb.com/
- http://www.leaflabs.com
- http://www.suntroncorp.com
- http://www.rapidboard.com/
- http://www.pca corporation.com/
- http://www.pcbassemblydepot.com/
- http://www.flexone.com/

INFO needed for a quote -
- Board quantity
- Unique parts
- Both Sides?
- Lead-free?
- # of SMT parts
- # of through hole
- # of fine pitch / QFM items
- Jumper wire? (if you made mistakes)
How to order PCB assembly

• You can ask them to order the parts or you can send them the parts.
• Files needed -
  – Bill of Materials (BOM)
  – Centroid data
    • Centroid data (aka Insertion or Pick-and-place or XY data) - This is the machine file, which should include: X, Y, Theta, Side of Board (Top or Bottom), and Reference Designator.
• The BOM from Eagle is not the format that they like.

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For generating Centroid data, see http://www.screamingcircuits.com/services/how-it-works.aspx#eagle
Pick and Place

http://www.youtube.com/watch?v=S8qkaTsr2_o&feature=related