PCB Design and Layout
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Overview

- High level description
- Basic definitions
- Schematic and layout tips
- Choosing components
- Companies for manufacturing and sponsorship
- General tips
Why custom board design?

- Form factor
- Design experience
- Tunable parameters (cutoff voltage, current draw, area, # of channels...
How custom should I go?

(Example: battery management)

- No custom electronics
  - Off the shelf: input and output power, communication to read status of pack
- Custom electronics with specialized ICs
  - Dedicated battery management IC
- Lower level implementation
  - Voltage, current, and temperature regulation done independently
Definitions

● Printed circuit board (PCB)
  ○ Mechanical platform for connecting and holding electrical components in place

● Embedded system
  ○ Computer system used to directly manipulate a hardware function/parts
  ○ Real-time computing

● Computer-aided design (CAD)
Definitions (cont.)

- **Schematic**
  - Graphical/symbolic description of interconnects

- **Layout**
  - Representation of final (physical) board
  - Interconnects and element mounting in copper
Task Breakdown/High Level Description

- “What”
- What does the board need to accomplish?
- Setting goals and design priorities for the task
Tips for Researching (Example: Custom motor controller)

- “How”
- Common implementations
  - Industry and hobbyists
- Functionality
- Feasibility
- Tradeoffs
Setting a Design

(Example: Custom motor controller)

- “How”
- Consider the mechanical and software constraints of your vehicle
  - Type of motor
  - Motor specs and inputs
  - Battery output power
  - Communication protocol (RS232 for reduction in noise susceptibility)
Design Software

- Electronic CAD software for schematic design and PCB board layout
  - gEDA
  - EAGLE CAD
- When deciding which software to use
  - Cost (accessibility for all members)
  - Number of layers
  - Built in libraries
Schematics

- Graphical/symbolic representation of the design
  - Describes component interconnects
Choosing the Right Parts for me

- Do your research
- Samples and sponsorship
  - TI, Analog Devices, Linear Technology, Microchip, Maxim Integrated…
  - If you’re a student, university sponsorship
- Added complexity to other systems?
  - e.g. “Does this ADC need an external reference voltage?”
Tips for Schematic Design

- Complete the schematic systematically to avoid forgetting something
- Lay items in an easy to follow manner
- Labeled fully
  - Netnames (connections between components) are named explicitly, device identifier is unique...
Layout

- Design of the physical PCB, plan location of components
- Layout should make sense from start to finish, group relevant components on the schematic together
More on Choosing Components

- What footprints can I solder by hand?
  - Chip resistors and capacitors down to 0603
  - Packages with thru hole mounting or “gull-wing” pins
  - Note: for more compact designs, you can look into using a reflow oven and solder pasted to populate more difficult footprints
Choosing the Right Connectors

- What are my power requirements?
- Board-to-wire versus Blindmate connectors
Tips for an Effective Layout

- Plan the location of components well for easier routing
- Avoid sharp angles on “high speed” signal traces to reduce reflections
- Place decoupling capacitors near the pins they are decoupling
- Plan out location of power and gnd rails to minimize return path
- Do not form closed loops in traces as that will form antennas around the board
- Use testpoints and status LEDs to help debugging process

**If you’re interested in more tips, send me an email and I’d be happy to send a more complete list**
Tips for an Effective Layout (cont.)

- Confirm the settings before doing anything
- Design Rule Checker (DRC)
  - Property of the printing company: sets valid copper width and spacing in order for the company to print (typically around 8-10mil spacing and 10mil rings)
  - mil = 1/1000 inches
- Number of layers (we do 2-4 depending on the board)
  - Shielding properties from dedicated ground plane
  - Cost considerations
Board Manufacturing

- Gerber files
- Our primary manufacturer: Nexlogic
  - roughly 2 week lead time for printing boards
Board Testing and Debugging

● Populate board “in order”
  ○ Power regulators for proper output
  ○ ICs and “innermost” components

● Well labeled test points and LED indicators will allow for debugging by inspection and multimeter while the board is still in the vehicle
Keeping an Aggressive Schedule

- Steps to a finalized design
  - Research
  - High level design
  - Schematic
  - Simulations
  - Layout
  - Soldering
  - Testing and debugging
  - Iteration
Keeping an Aggressive Schedule (cont.)

- Board design during Fall semester (4 months)
- Soldering and implementation (1 month)
- Testing and debugging (5 months)

Remember:
- Board printing (2-4 weeks)
- Ordering parts (4-7 days)
- Sample requests (3-14 days)
Keeping an Aggressive Schedule (cont.)

- Multiple stage design reviews
  - Smaller design review with subteam leader
  - Full electrical team review
Don’t Forget your Documentation!

- Technical design documents
  - Research and resources
  - How the design works at a high level
  - Breakdown each section
  - Improvements for future revisions of the project

- User Manual
  - How to populate and test the PCB
  - How to use in the vehicle
  - Possible failure modes
Tips for Custom Board Design

- Research previous implementations
- Aggressive scheduling
- Schematic design
  - Choosing the right components
- Layout design
- Integration and Testing
- Iteration
- Documentation
Questions?