

Electronic System Design: From Concept to Prototype

- ① Microcontroller Selection
- ② Electronic System Prototyping
- ③ Electronic System Manufacturing Processes

Electronic Systems Design - Reflection

Electronic Systems Design will be used as an example.

Self-Reflection

What microcontrollers are you currently familiar with and how did you select them?

Have you developed separate modules that have to communicate with one another?

When designing electronic systems, what techniques do you use during prototyping / concept development / deployment / manufacture?

What do you think you could improve most about your electronic system design?

Systems Design - Micro Selection and System Prototyping

① Microcontroller Selection

- Peripherals
- Processing Capability
- Package Options
- Programming Features (Eg. Bootloaders)
- Minimum Circuitry

② Electronic System Prototyping

- Breadboard
- Vero-board use and Design Tools
- Development Boards

③ Electronic System Manufacturing Processes

- Milled and Etched PCBs
- Gerber File Format

Microcontroller Selection - Needs Analysis

The System Architecture (SA) diagrams discussed in the previous lecture are a good tool to help decide which microcontroller or processor is required to perform a task.

The SA diagram should go through multiple revisions to ensure that it is an efficient, streamlined, future-proof, perhaps modular, robust system.

Microcontroller Selection Considerations

- How many of each communication bus are required?
- How many specific / additional peripherals are required? Eg. Analog pins or digital pins?
- How is the processor to be programmed?
- What is the minimum circuitry

Microcontroller Selection - Needs Analysis

Microcontroller Selection Considerations Continued

- What processing or loop frequency is required?
- Are there any energy considerations? Eg. Low power, battery operated?
- Are there any erratum in this chip family?
- Are there development boards available for prototyping and to test the chip / code?
- What kind of protection circuitry is required?
- What chip package can your manufacturing technology handle?

Microcontroller Selection - Peripherals

Microcontroller Peripherals - Systematic Approach

- Based on the SA diagram, record the minimum number of each communication and peripheral feature. Include future-proofing requirements.
- Determine the voltage level requirements of each interface to determine the most suitable controller voltage (Eg. 3.3V, 5V?)
- Specify the maximum current the pins are expected to sink or source.
- Determine the frequencies required for communication (eg. USB may be very specific)

Microcontroller Selection - Processing Capability

Microcontroller Capability - Systematic Approach

- Determine the required word length. Eg. Is an 8-bit architecture enough? or is a 16/32/64 bit word length required?
- Determine the anticipated workload of the controller. Use this to conservatively estimate the required instruction and clock frequencies.
- Specify how much processing memory and program memory are required.
- Are features such as Direct Memory Access (DMA) required?

Microcontroller Selection - Chip Package

Microcontroller Package - Systematic Approach

- Determine the system manufacturing technology.
Through-hole or Surface Mount?
- Specify the soldering technique (Eg. pick-and-place, hand soldered, reflow?). This will limit what options are available.
- Research the pad layout requirements from datasheets for standard packages.

Microcontroller Selection - Specification

So far, the System Architecture diagram will have had multiple revisions, and be close to a firm prototype specification.

Through the systematic methods of microcontroller specification detailed in the previous slides (Needs Analysis, Peripheral Selection , Processing Capability, and Chip Packaging) we have detailed the minimum requirements.

Additional Features / Requirements

What other considerations should be made during procurement?

Microcontroller Selection - Additional Requirements

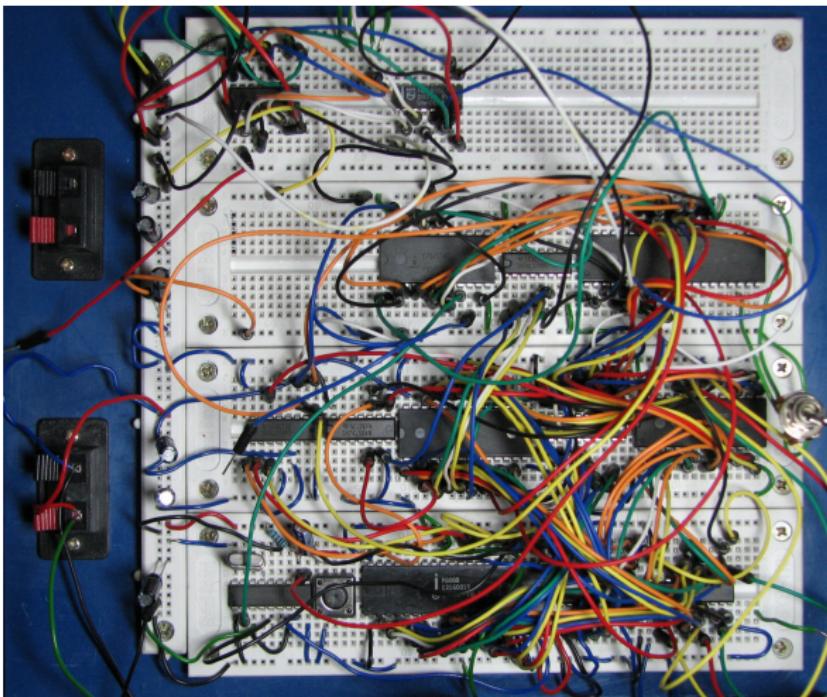
Consider how the system is intended to be programmed. Some microcontrollers require specialist programmers, while others are shipped with bootloaders. This is especially important if you intend to update products in the field (Eg. Firmware upgrade)

Find out the minimum circuitry required to start the chip running. Some are more involved than others.

Check for erratum documents - Early-mid phase microcontroller products typically have a few features that do not work as expected. The datasheet may not be 100% correct.

Electronic System Prototyping - Breadboard

Who has made one of these?



Electronic System Prototyping - Breadboard

Breadboard is a good place to start for prototyping purposes, particularly for analog circuits.

Of course it can be used to test digital circuit design, motor driving, and communications, though you need to be careful.

- The number of terminals at any node are limited
- For communications, be aware of capacitive effects of the parallel tracks
- Breadboard is not designed for high current applications. eg Driving a powerful motor
- Breadboard is prone to wires pulling out, which change the circuit

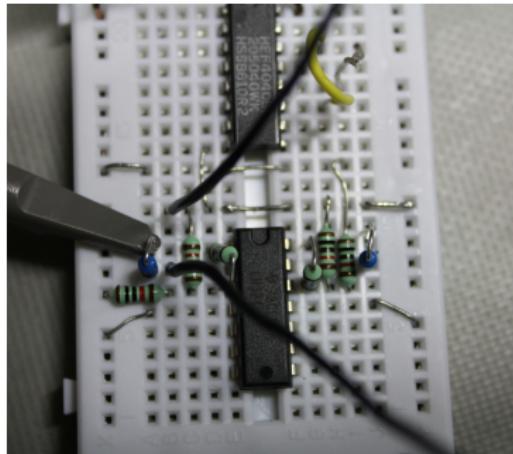
Electronic System Prototyping - Breadboard

When to use breadboard

Breadboard should be used to:

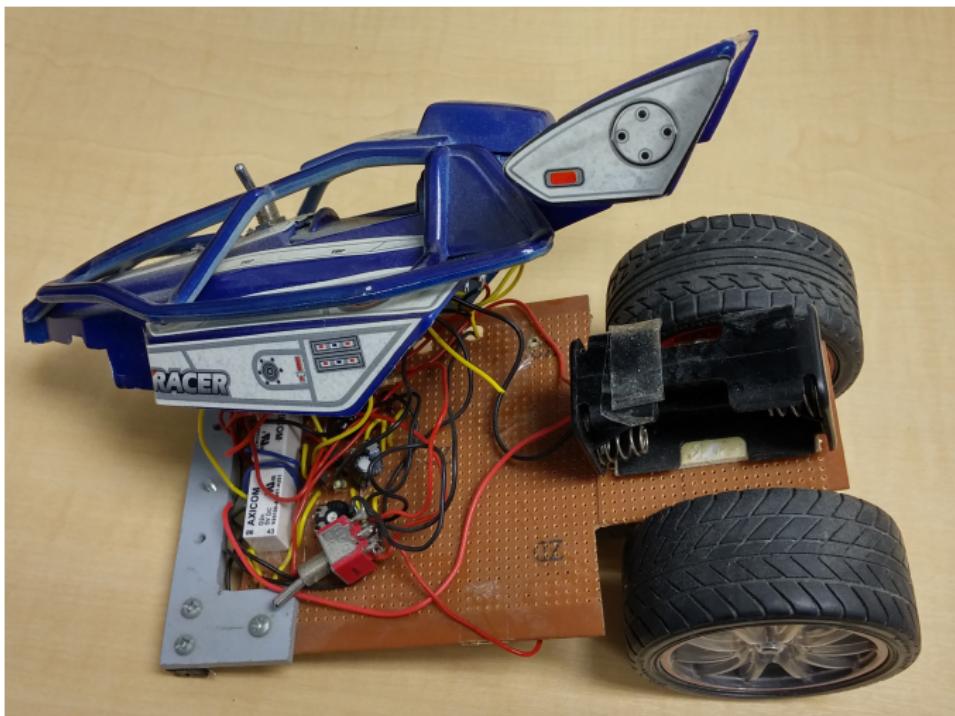
- prototype and validate circuit design
- ensure minimum functionality
- check that components work as expected and raise confidence in the circuit design

Circuits should be laid out in a tidy manner such that they can be reconciled. Design changes are easy here.



Electronic System Prototyping - Why to use Veroboard

Who has made one of these?



Electronic System Prototyping - Veroboard

If circuits require higher current, or some confidence has been established for a module, it can be prototyped on Veroboard.

This makes the circuit more reliable than Breadboard, but is still very much a prototype.

It is usually easiest to design vero board circuits with the tracks running horizontally, and the components running primarily vertically. Presumably because we are trained to read left to right, top to bottom.

So how can Veroboard be used effectively?

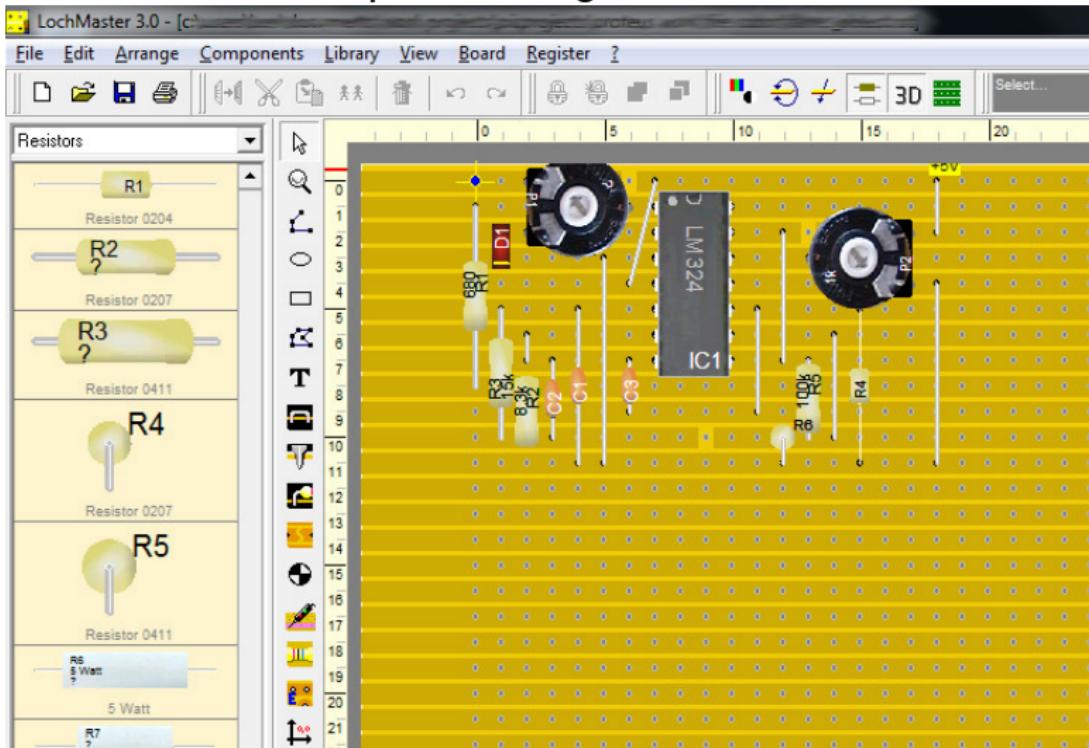
Electronic System Prototyping - Using Veroboard

A Systematic Approach to Vero Design

- ① Draw the circuit in a schematic manner (eg. Circuit diagram)
- ② Use paper with dots, or a software tool to lay out the circuit.
- ③ Revise the layout - rinse and repeat.
- ④ Manufacture the circuit from the diagram.

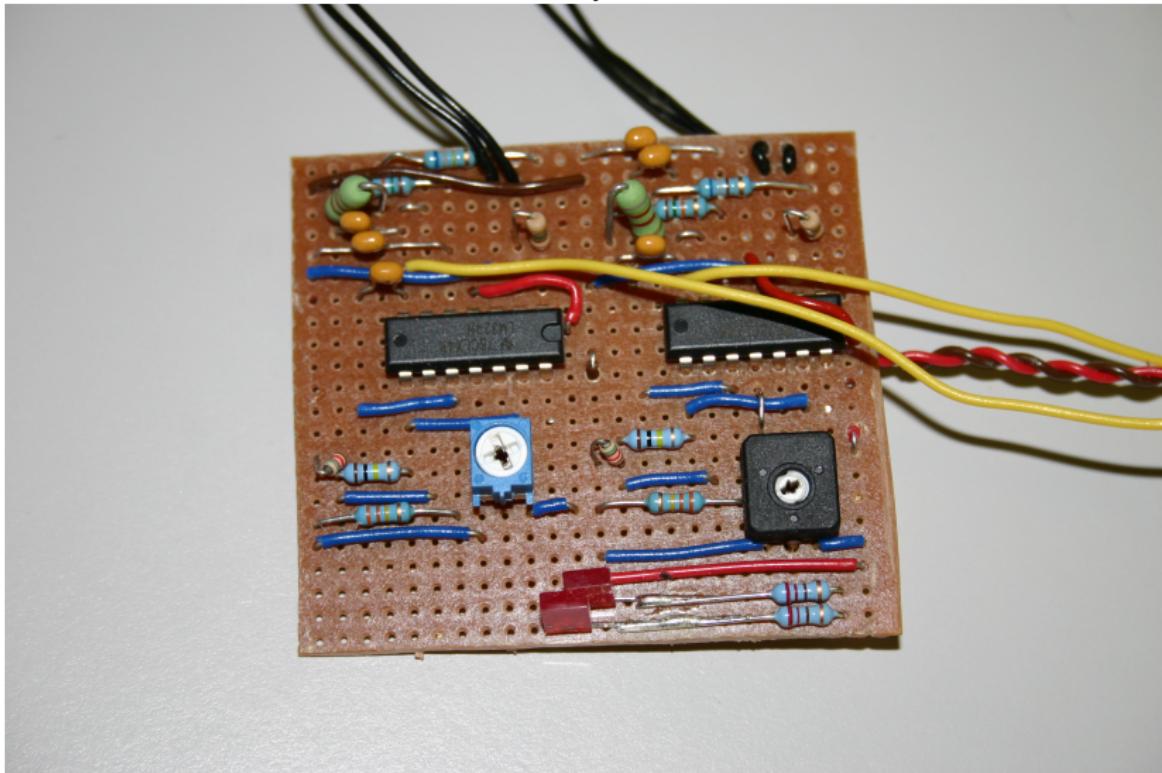
Electronic System Prototyping - Veroboard (LochMaster)

Example of using LochMaster



Electronic System Prototyping - Using Veroboard

2x circuit from previous slide



Electronic System Prototyping - Printed Circuit Boards

Once there is some confidence in the design printed circuit boards can be developed.

This is the most important time to have a firm system architecture diagram, and apply structured design methodologies.

At the earlier prototyping phases, the repercussions of mistakes are easier and faster to fix. Once proceeding to PCBs, this becomes more challenging and typically requires starting the manufacturing process again.

Printed Circuit Board Design and Tools

In order to create PCBs a range of design considerations need to be made.

A schematic capture and PCB layout program is required, which may also offer features such as circuit simulation and CAD model outputs in addition to the circuit board manufacturing files.

PCB Design Software

Which PCB softwares are you familiar with?

Are there any which are better than others?

Research the advantages and disadvantages of each possibility.

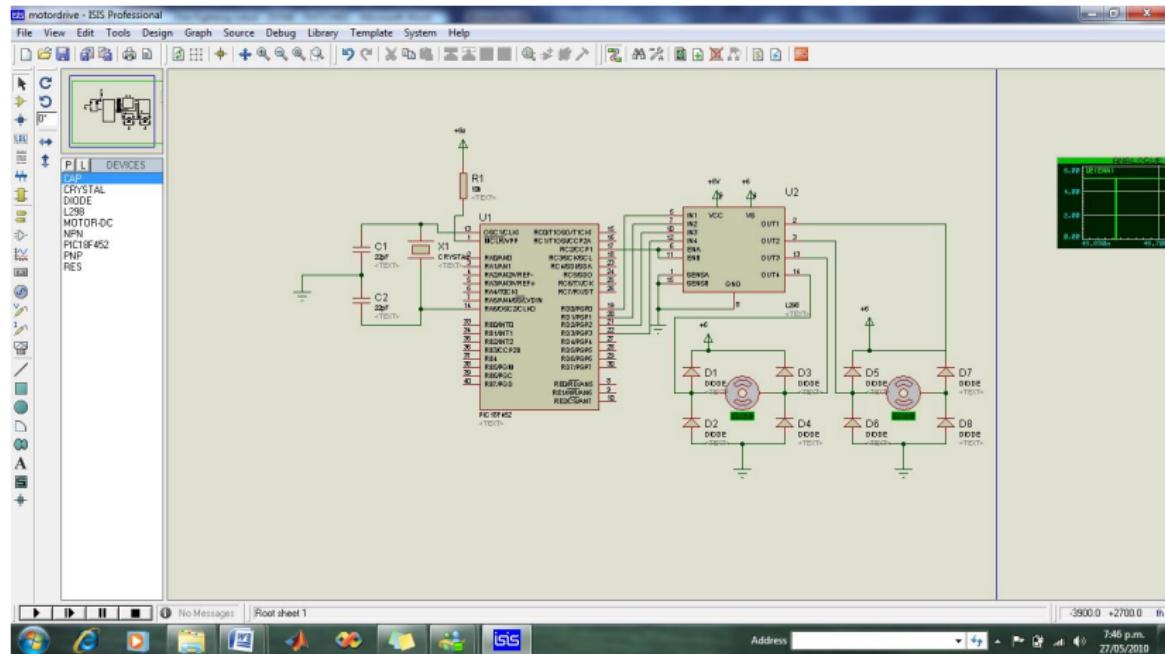
Printed Circuit Board Design and Tools

Examples of PCB schematic capture and layout software:

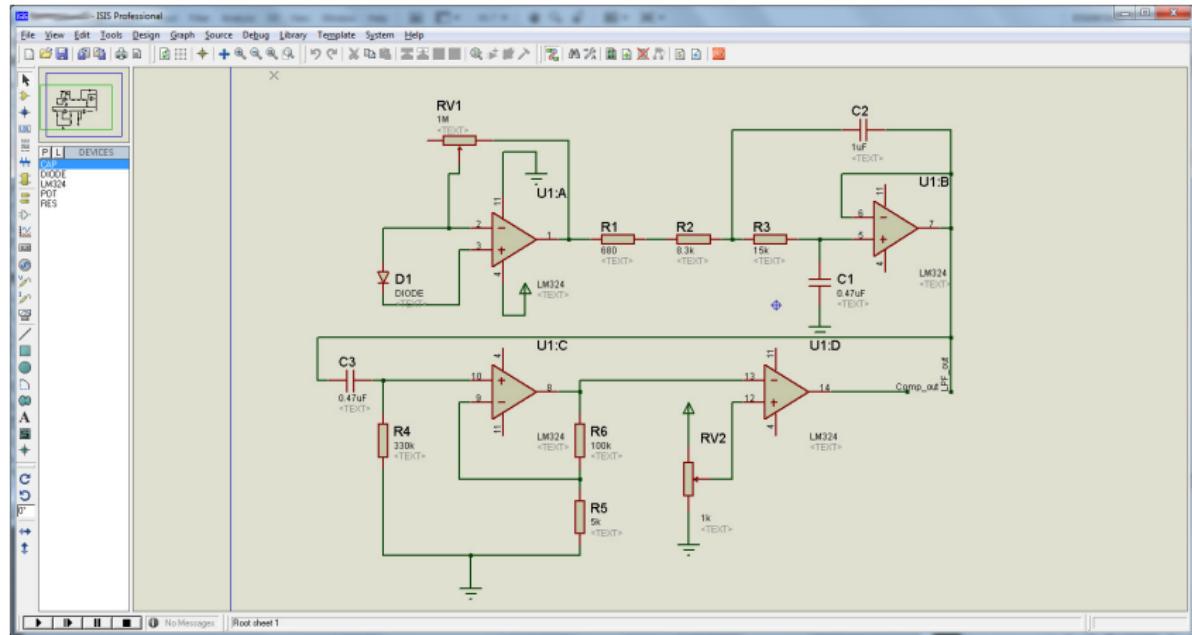
Name	Manufacturer
Proteus	Labcenter Electronics
Altium	Altium
Eagle	Farnell
Design Spark	RS Electronics

So how do they differ?

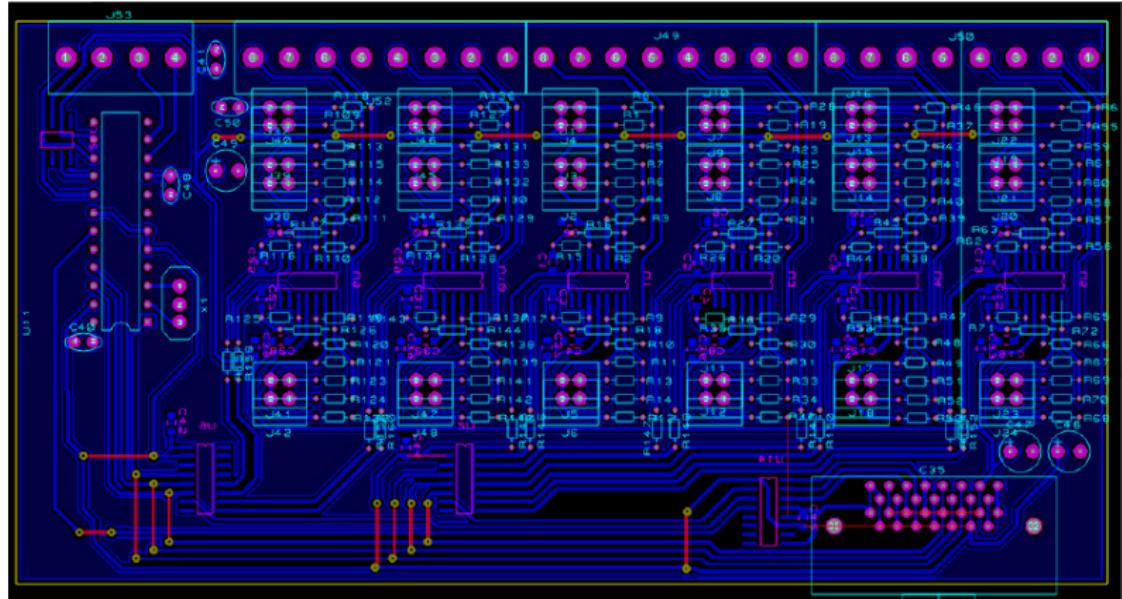
Printed Circuit Board Design - Schematic Capture - Proteus



Printed Circuit Board Design - Schematic Capture - Proteus

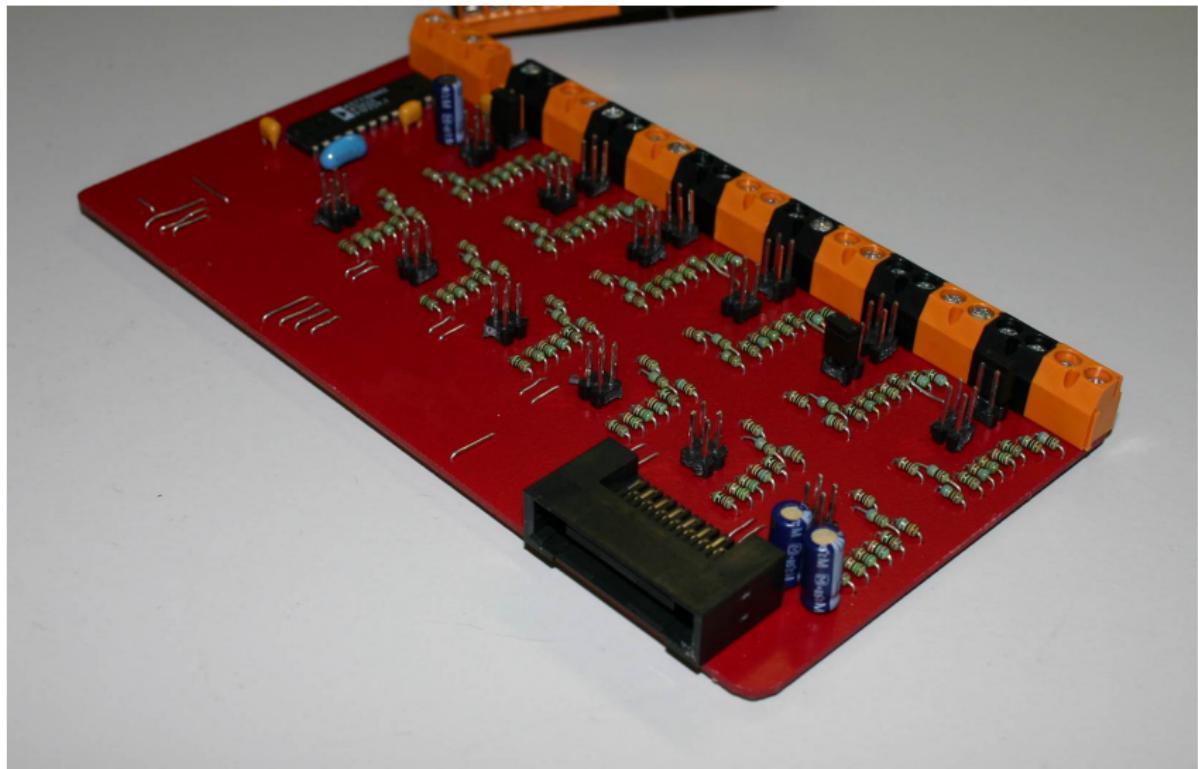


Printed Circuit Board Design - PCB Layout - Proteus



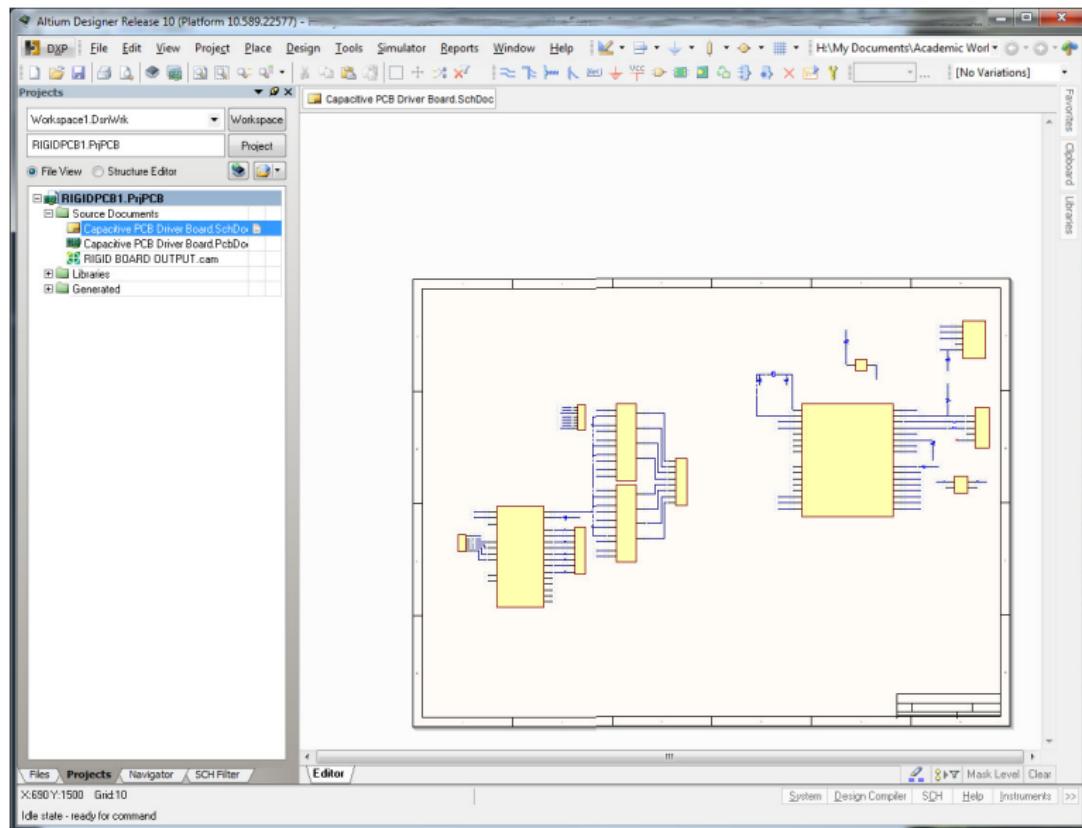
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Printed Circuit Board Design - Milled PCB (Massey)

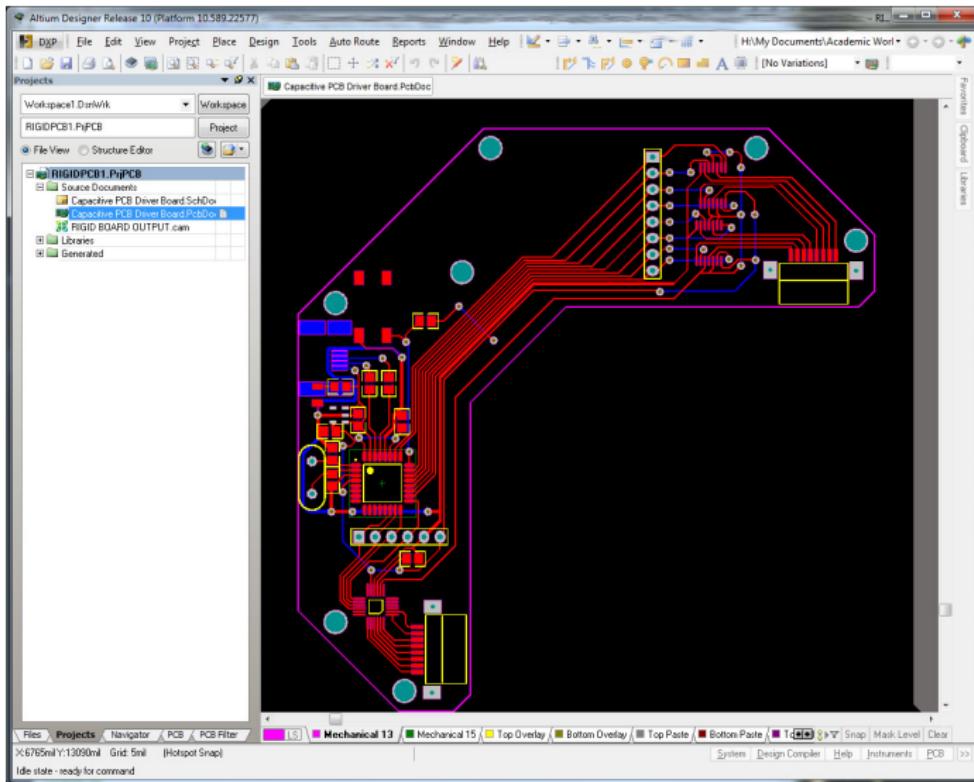


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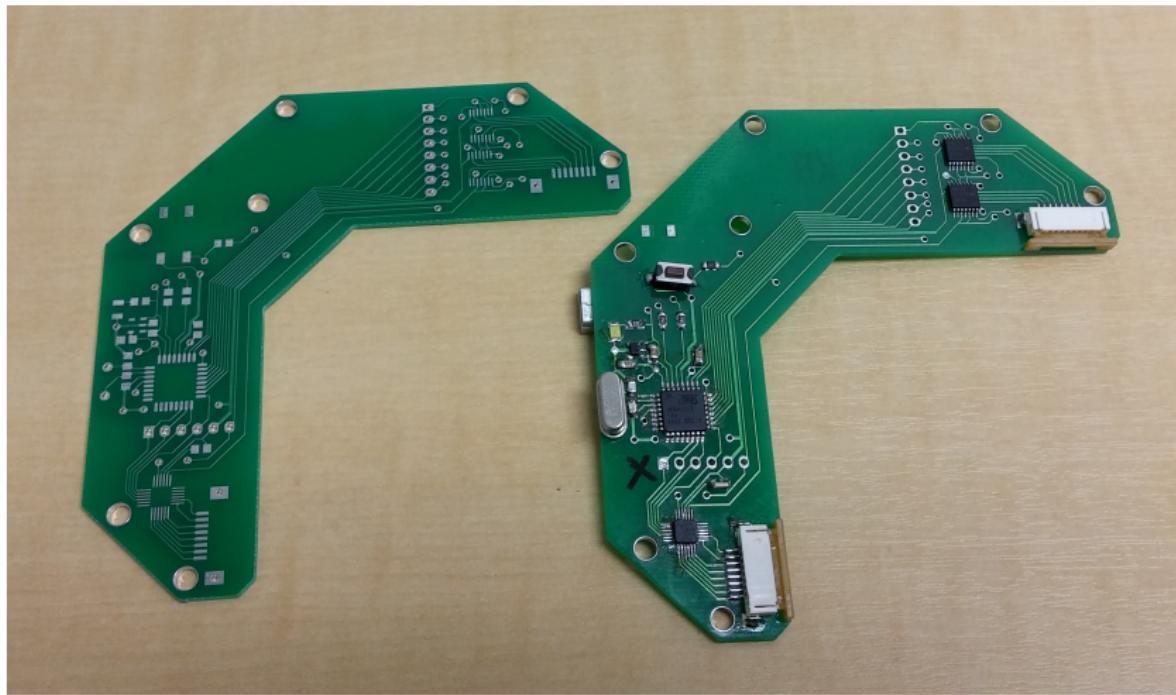
Printed Circuit Board Design - Schematic Capture - Altium



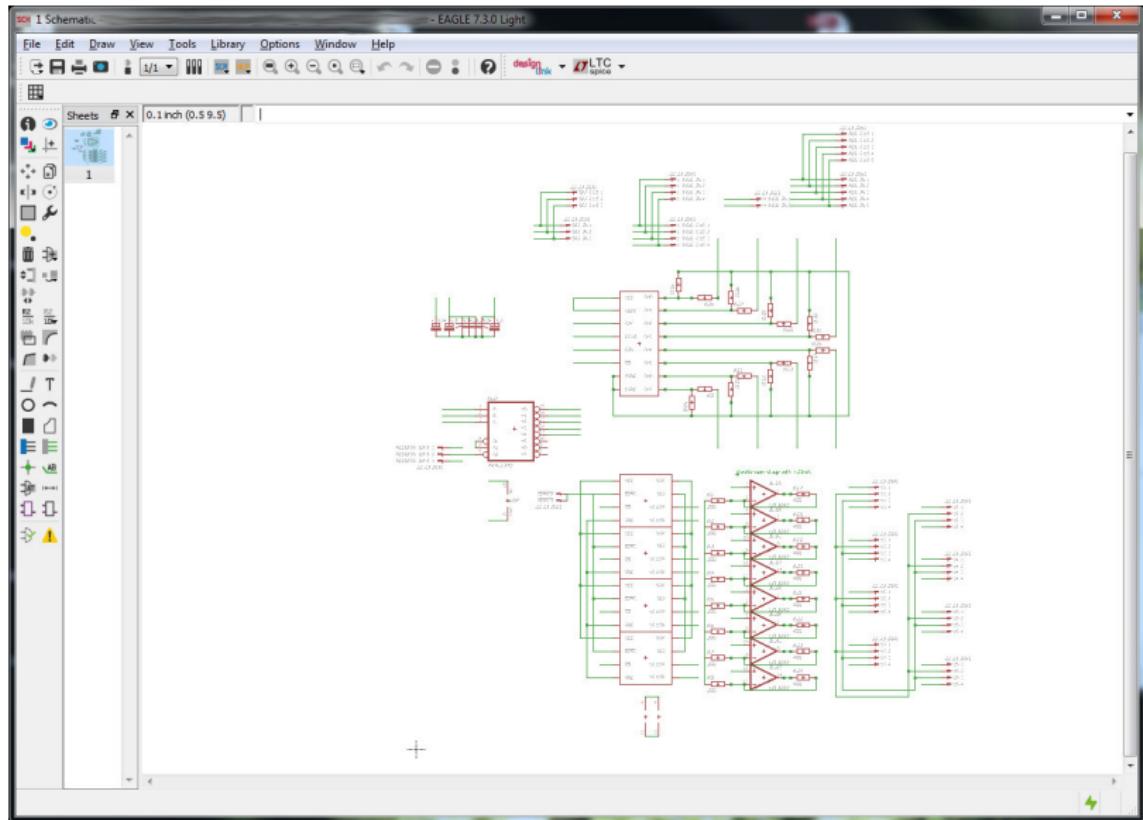
Printed Circuit Board Design - PCB Layout - Altium



Printed Circuit Board Design - Professional Etch

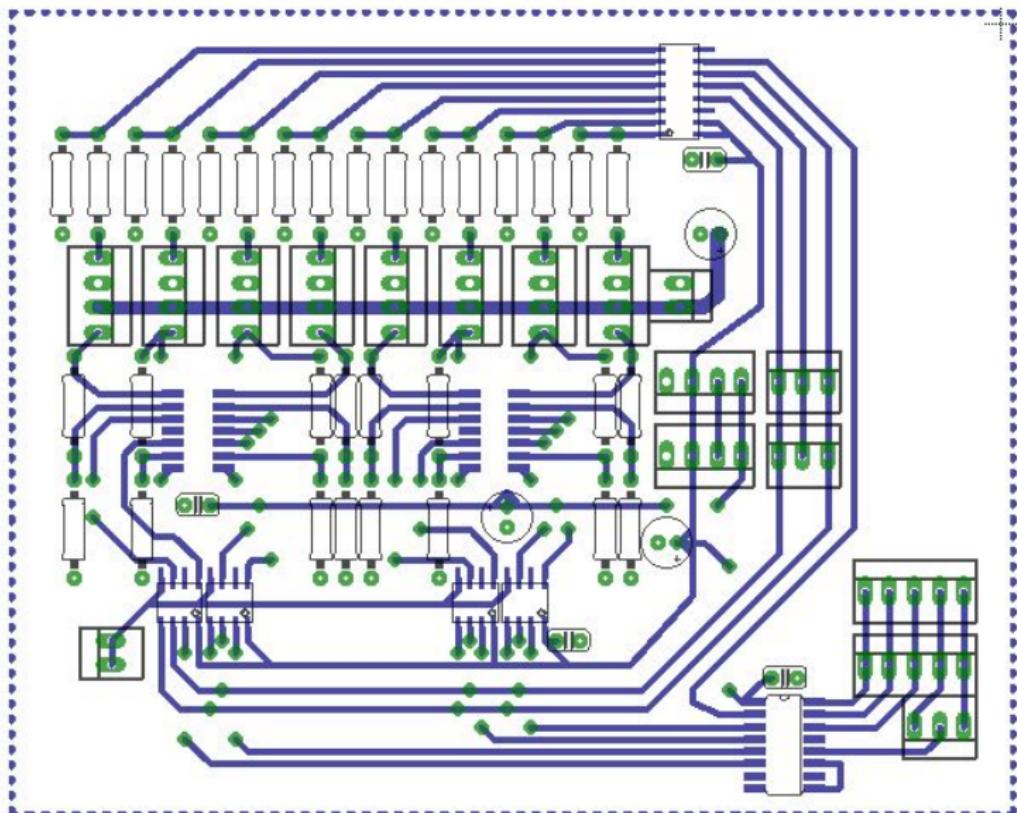


Printed Circuit Board Design - Schematic Capture - Eagle



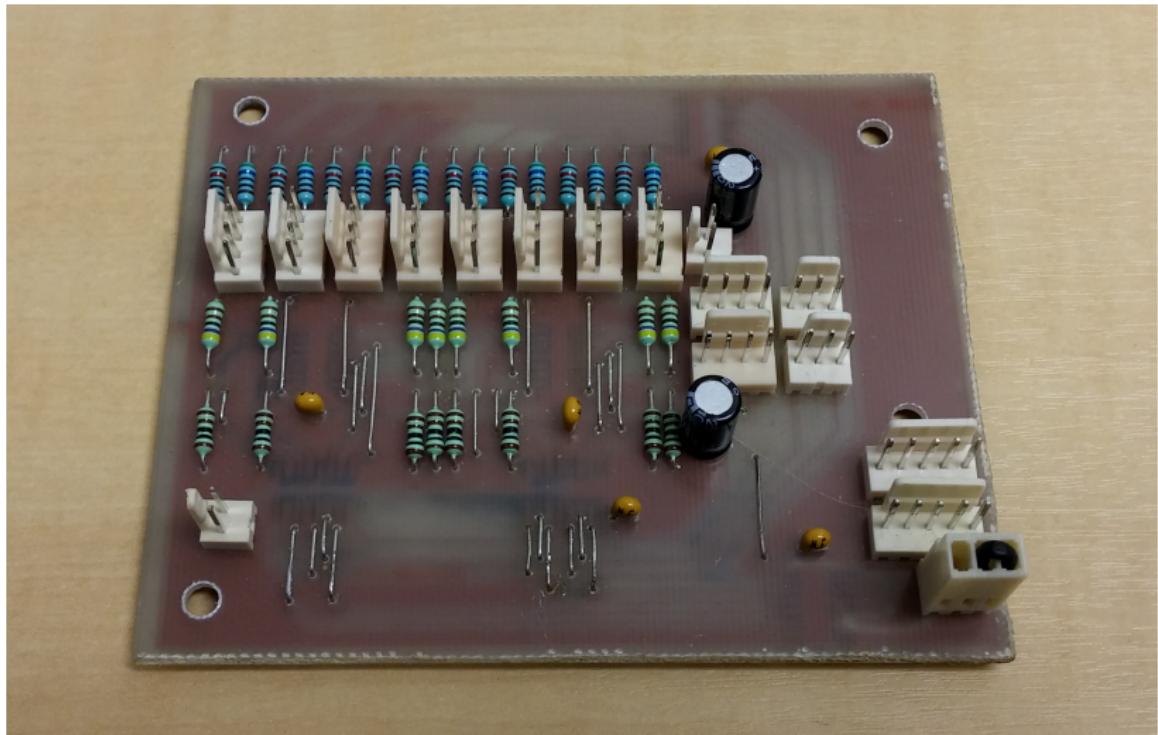
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Printed Circuit Board Design - PCB Layout - Eagle

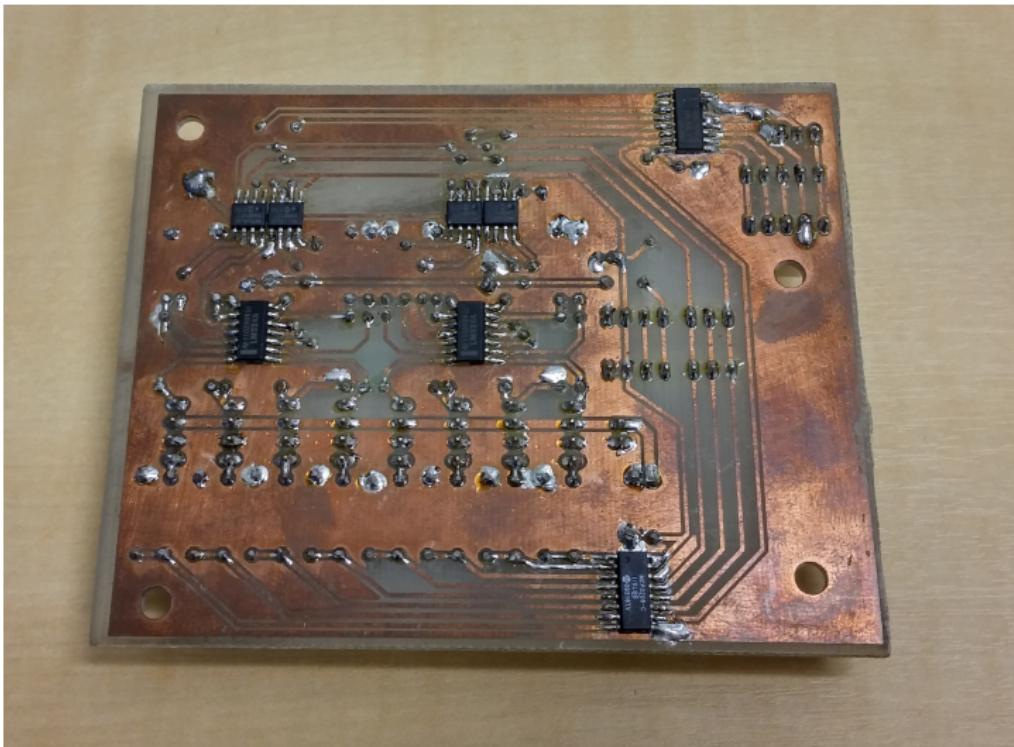


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Printed Circuit Board Design - Basic Etch

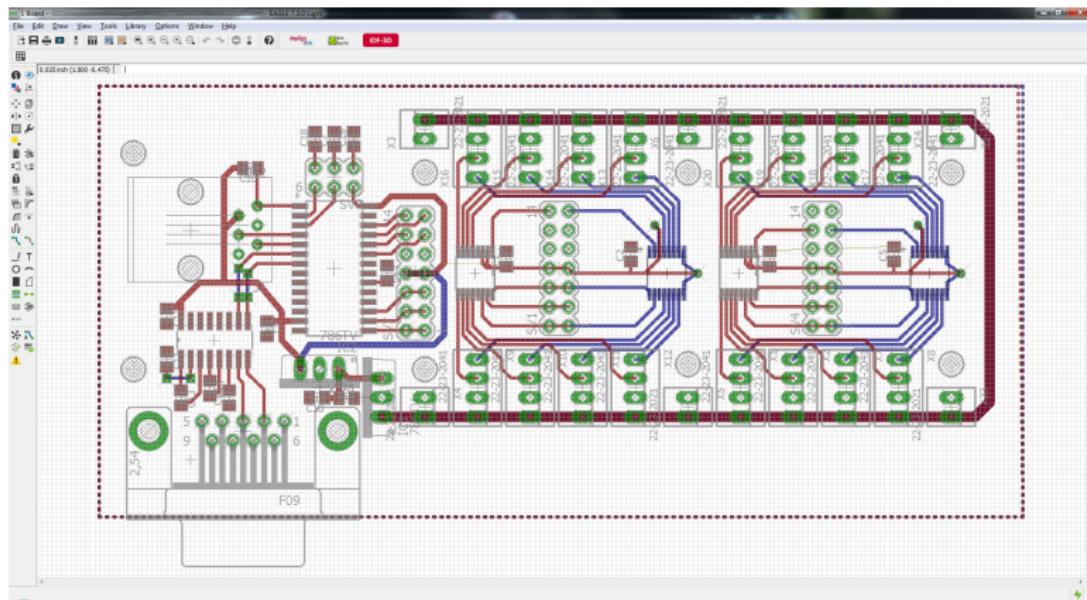


Printed Circuit Board Design - Basic Etch

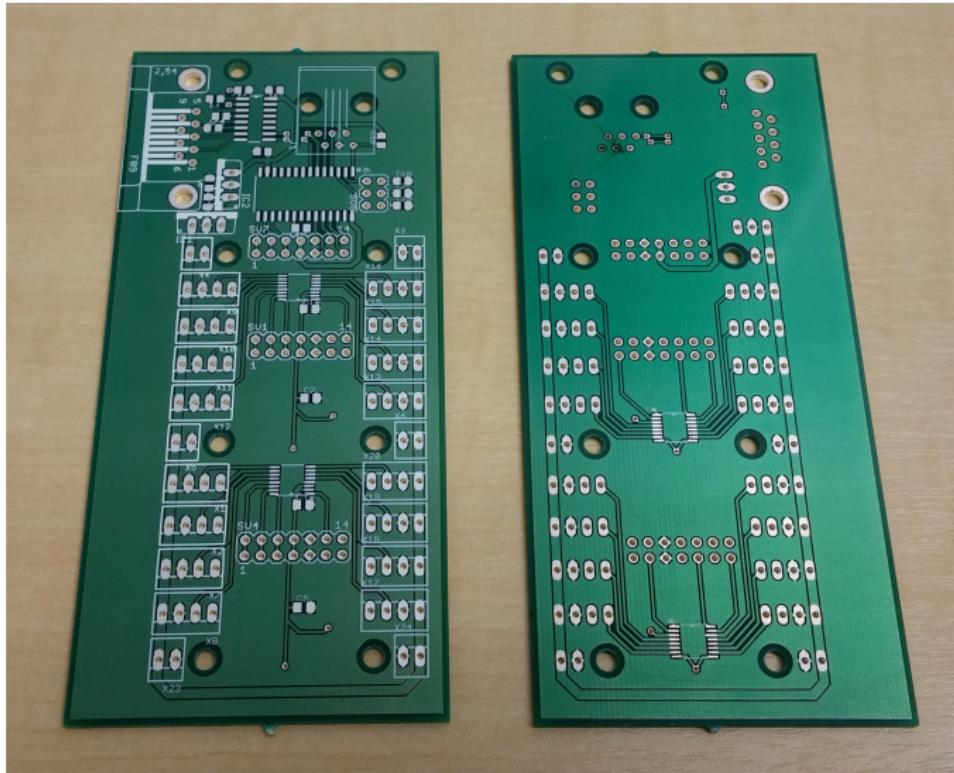


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Printed Circuit Board Design - PCB Layout - Eagle



Printed Circuit Board Design - Professional Etch



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