

**PCB
DESIGN SEMINAR
IEEE @ UC
ASWIN BALASUBRAMANIAM**

TOPICS EXPLORED

WHAT IS A PCB?

Printed Circuit Board

Custom designed boards built to function for a specific task

Replaces circuits built using wires

A PCB populated with electronic components is a printed circuit assembly (PCA)

PCBs are rugged, inexpensive, reusable, and highly reliable

HOW DO YOU MANUFACTURE ONE?

Using the Engineering Process

1. Understand (Identify the Problem/Task)
2. Design/Calculate
3. Simulate
4. Prototype/Manufacture

Design:

1. On Paper
2. CAD Softwares: Eagle (Part of Autodesk now), OrCAD, Proteus, Fritzing, TINA, FreePCB

Prototype/Manufacture:

1. List of vendors/manufactures provided in the handout

THE ENGINEERING PROCESS

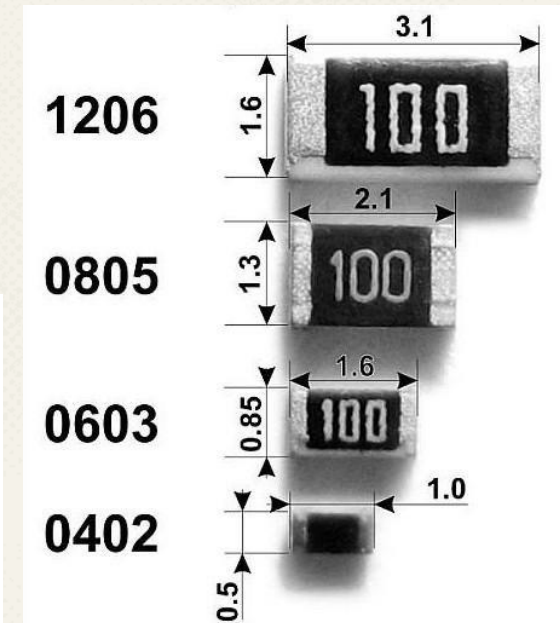
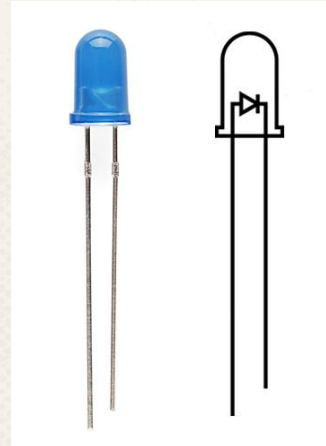


THE PROBLEM

A SIMPLE LED CIRCUIT

What do we need to build this circuit?

1. Voltage Supply
2. Resistor
3. LED (A color of your choice)
4. A switch



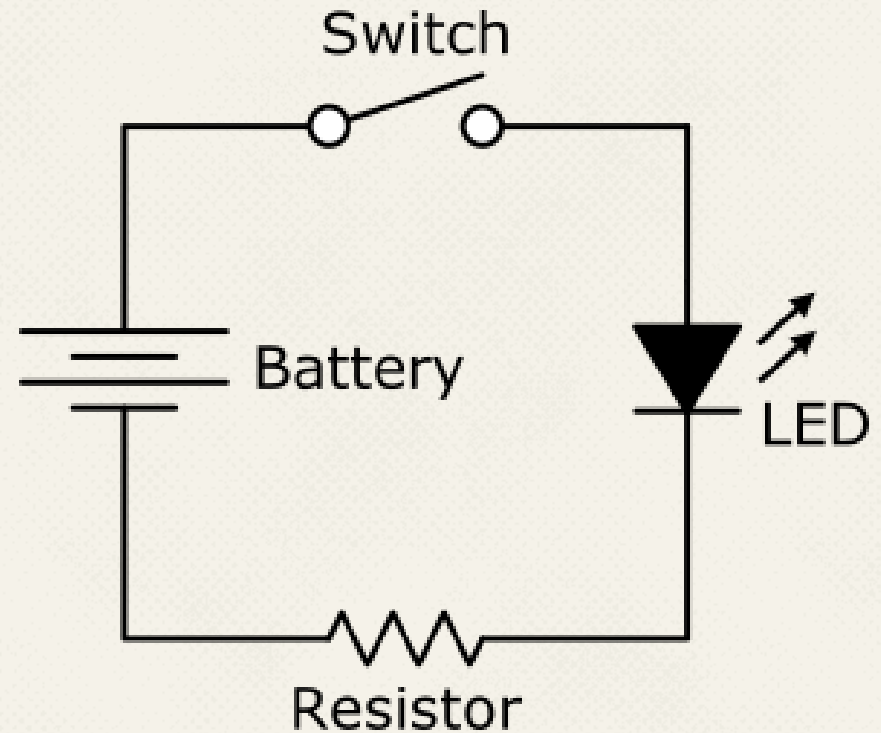
DESIGN/SIMULATE

CIRCUIT SCHEMATIC FOR THE LED CIRCUIT

1. 1.8V – 3.3V rated 20mA LED
2. 3V button cell (requires holder)
3. 140Ω resistor
4. Normally open (NO) button switch

SIMULATE

Simulation can be run on software like MultiSim.



DESIGNING ON PCB SOFTWARE

PARTS OF A PCB

Components

Pads

Traces

Vias

Top Metal Layer

Bottom Metal Layer

MATERIALS OF A PCB

Conducting layers are typically made of thin copper foil.

The board is typically coated with a solder mask that is green in color. Other colors that are normally available are blue and red.

Unwanted copper is removed from the substrate after etching, leaving only the desired copper traces or pathways.

COMPONENTS

- Components are the actual devices used in the circuit.
- This includes input/output connections.
- I/O ports, including power supply connections, are also important in the PCB design.

PADS

- Location that components connect to.
- You will solder components to the pads on the PCB.
- Pads will connect to traces.

TRACES

- Traces connect pads together.
- Traces are essentially the wiring of the PCB.
- Equivalent to wire for conducting signals.
- Traces sometimes connect to vias.
- High current traces should be wide.
- Signal traces usually narrower than power or ground traces.

VIAS

- Pad with a plated hole connecting traces from one layer of board to other layers.
- Attempt to minimize via use in your PCB design.
- Some component leads can be used as vias.

TOP METAL LAYER

- Most of the components reside on the top layer.
- Fewer traces on the top layer
- Components are soldered to the pads on the top layer of PCB.
- Higher circuit densities.

BOTTOM METAL LAYER

- Few components on this layer.
- Many traces on this layer.
- Most soldering done on this layer.

MULTILAYER PCBs

- More than just a top and bottom layer.
- Typical multilayer boards consists of a power plane, ground plane, top layer, and bottom layer.
- Sometime signal layers are added as needed.

JUMPERS

- Often, many signal wires need to exist in too small of a space and must overlap.
- Running traces on different PCB layers is an option.
- Multilayer PCBs are often expensive.
- Solution: Use Jumpers

PCB MANUFACTURING TIPS

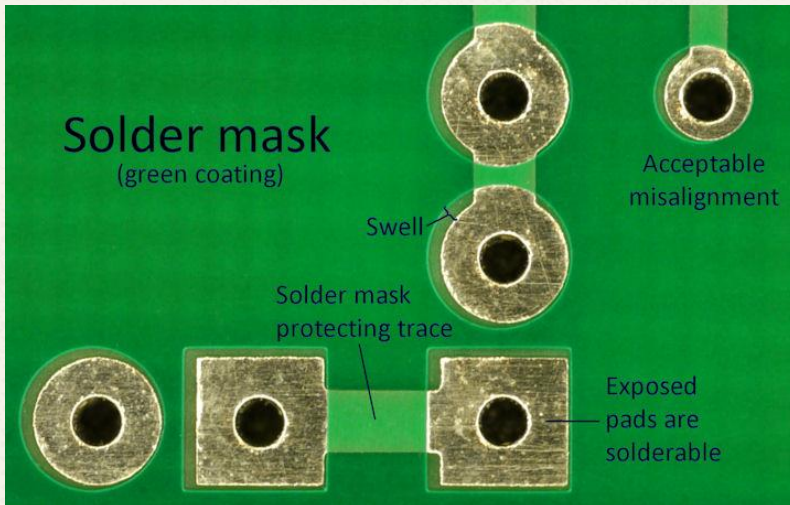
SOLDER MASK

Protect copper traces on outer layers from corrosion.

Areas that shouldn't be soldered may be covered with polymer resist solder mask coating

Designed to keep solder in certain areas

Prevents solder from binding between conductors and thereby creating short circuits.

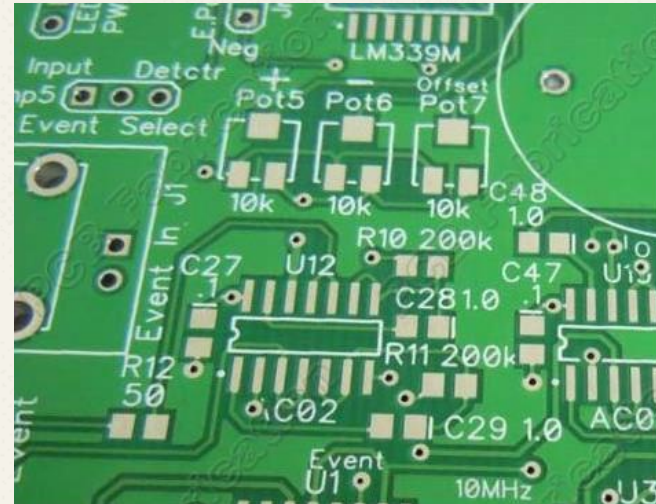


SILKSCREEN

Printing on the solder mask to designate component locations.

Readable information about component part numbers and placement.

Helpful in assembling, testing and servicing the circuit board.



PHYSICAL DESIGN

• **ISSUES**

● COMPONENT SIZE ●

- Making sure all the components will actually fit.
- This especially applies for circuits that require high component densities.
- The different types of mounting styles that exist are: SMDs and Trough Hole

● HEAT DISSIPATION ●

- Some components get really hot.
- Data sheets usually give information about their heat dissipations.
- Solution: Heat sinks, it dissipates heat off the component.
- Does not remove the heat just moves it.
- A short circuit may occur when two devices share the same heat sink.

● MOUNTING POINTS ●

- The PCB needs to be mechanically secured to something.
- It could be a chassis that consists of a metal frame, or a case where circuit boards or other components can be mounted.
- Could also need heatsink attachments
- Screw hole size needs to be known prior to designing these points on the board.

ELECTRICAL DESIGN

• **ISSUES**

SERIES INDUCTANCE

- Not an issue for low frequency circuits (<10 MHz)
- The inductance of a trace may be significant.
- For power connections, a shunt capacitor is added to counter the series inductance of a long trace.

SHUNT CAPACITANCE

- Results of wide traces, over a ground plane.
- Limits speed of circuits, including digital circuits.
- Typically insignificant for low performance circuits.
- To minimize this effect, place a capacitor from voltage to ground.

INDUCTIVE COUPLING

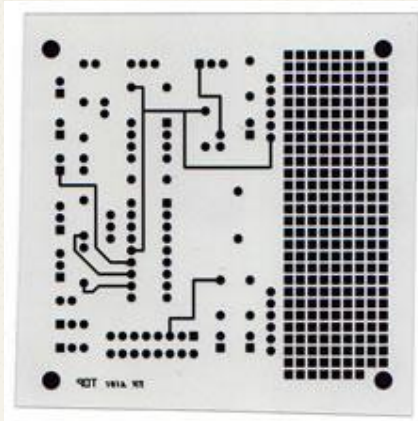
- Transfer of energy from one circuit component to another through shared magnetic field.
- Change in current flow through one device induces current flow in other device.
- Current flow in one trace induces current in another trace.
- Solution: Minimize the long parallel runs of traces.
- Run traces perpendicular to each other.

MANUFACTURING THE BOARD

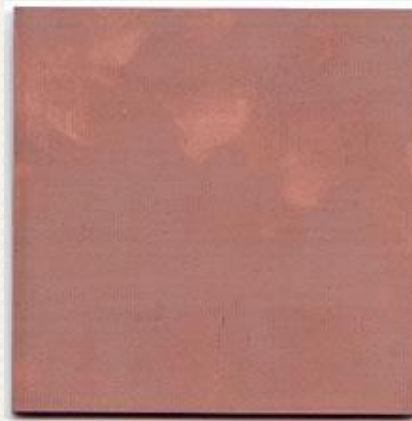


STEPS IN PCB MANUFACTURING

1. FILM GENERATION

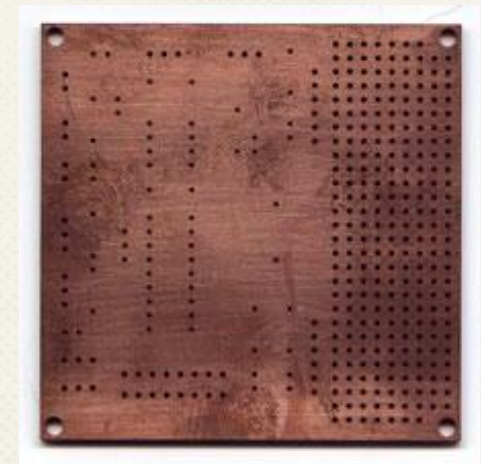


2. SELECT THE BOARD MATERIAL



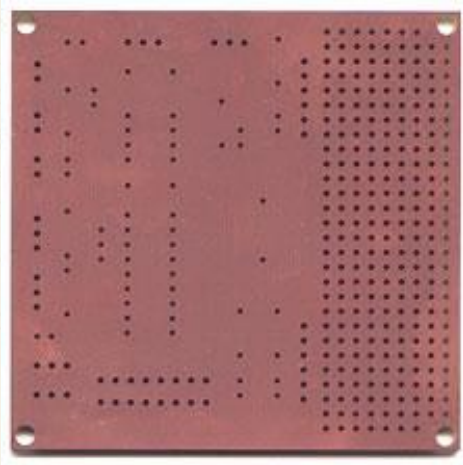
Industry standard is 0.050"
thick, copper clad, two
sides

3. DRILLING HOLES



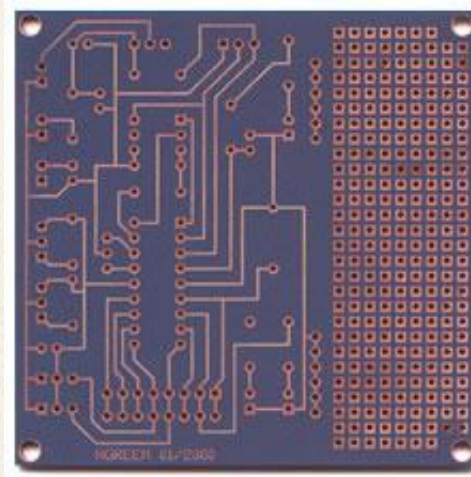
STEPS IN PCB MANUFACTURING

4. ELECTROPLATE COPPER



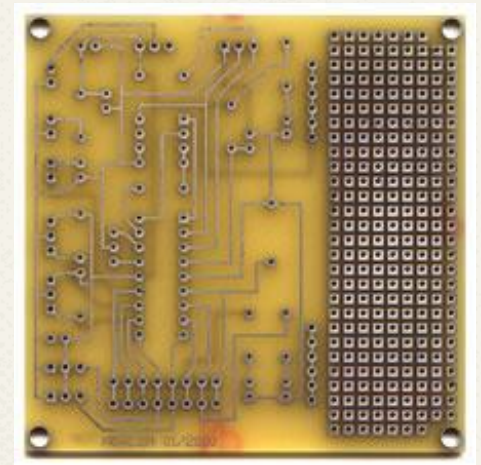
Apply copper in hole barrels

5. APPLY IMAGE



Apply photosensitive material to develop selected areas from panel

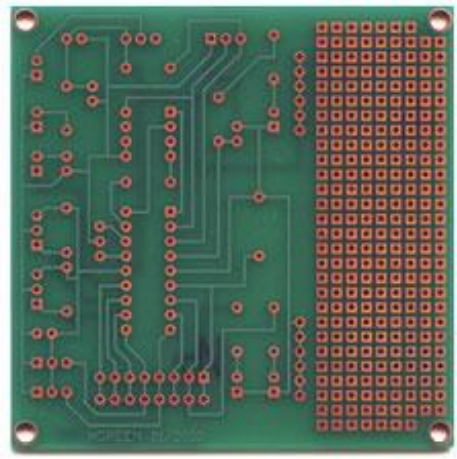
6. STRIP AND ETCH



Remove the dryfilm, and etch the exposed copper. The tin is used as an etch resist and ensures the trace and pad definition are maintained during the later stages

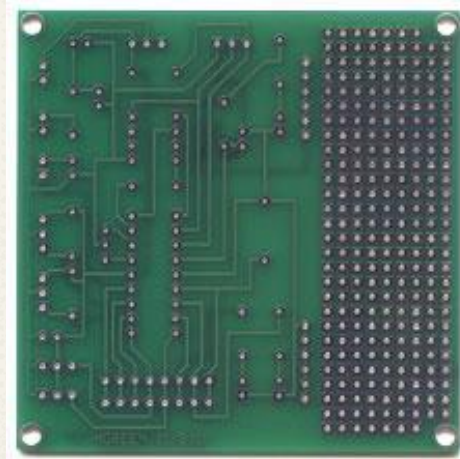
STEPS IN PCB MANUFACTURING

7. APPLY SOLDER MASK



Apply solder mask area to entire board with the exception of solder pads, and traces

8. APPLY SOLDER COAT



Apply solder to pads

9. SILKSCREEN



Apply silver letter marking using screen printing process

USEFUL LINKS

- https://www.youtube.com/watch?v=VXE_dh38HjU: EEVblog: (3 Part Video Tutorial)
- <https://www.youtube.com/watch?v=N3DGbwVXyN8>: PCB Etching
- <https://www.youtube.com/watch?v=Q6WJqjVleG0&feature=related>: Making PCB at home

REFERENCES

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- Ardizzoni, John. “A Practical Guide to High-Speed Printed-Circuit-Board Layout.” *A Practical Guide to High-Speed Printed-Circuit-Board Layout | Analog Devices*, www.analog.com/en/analog-dialogue/articles/high-speed-printed-circuit-board-layout.html. Accessed 30 Sept. 2017.