

# EE-100 Engineering Laboratory

## **Module1: PCB**

Dr. –Ing. Ahmad Kamal Nasir

**[Office Hours]**

Tuesday (1000-1100)

Friday (1000-1100)

Room 9-345A (EE Dept. Right Wing)

Module 1

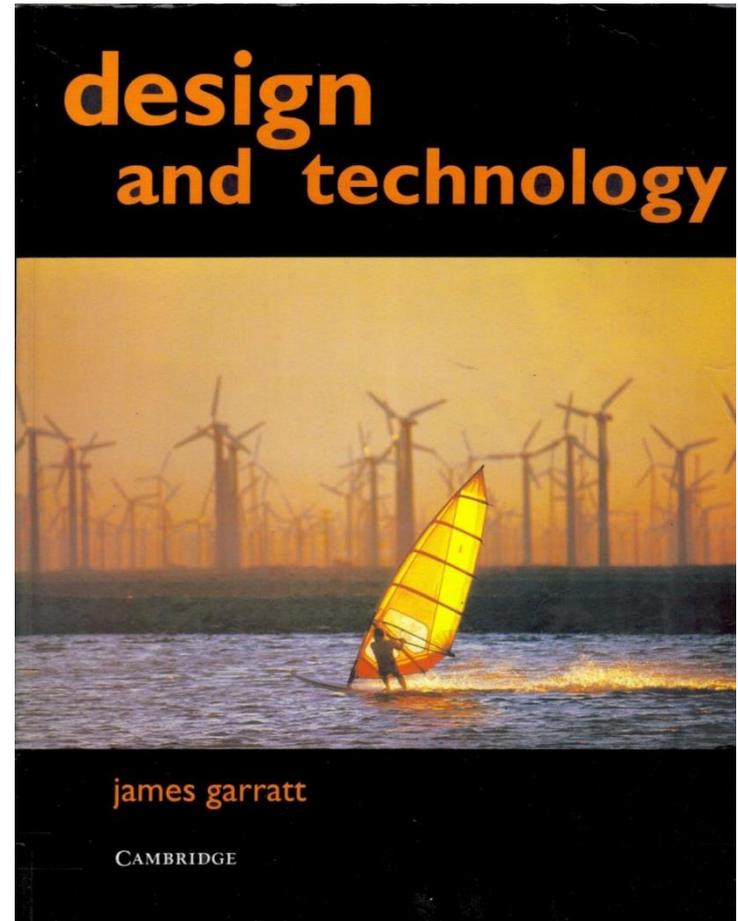
**WEEK1**

# PCB Module

- Week 1
  - Introduction to basic electronics components
  - Introduction to conventional/non-conventional PCB fabrication
  - **Lab Visit:** Overview of workshop facilities
  - **Demonstration** of etching and soldering
  - **Demonstration** of PCB CNC milling and drilling
- Week 2
  - Introduction to Proteus ISIS
  - Introduction to circuit **schematic design** and simulation
  - **Tutorials:** Create computer schematic and simulate circuit
  - **Lab Task 2:** Create schematic drawing in Proteus ISIS
- Week 3
  - Introduction to Proteus ARES
  - Introduction to circuit **layout design**
  - **Tutorials:** Create computer PCB layout for electronic circuits
  - **Lab Task 3:** Create Layout drawing in Proteus ARES
- Week 4
  - **Lab Task 4:** PCB Soldering and Troubleshooting

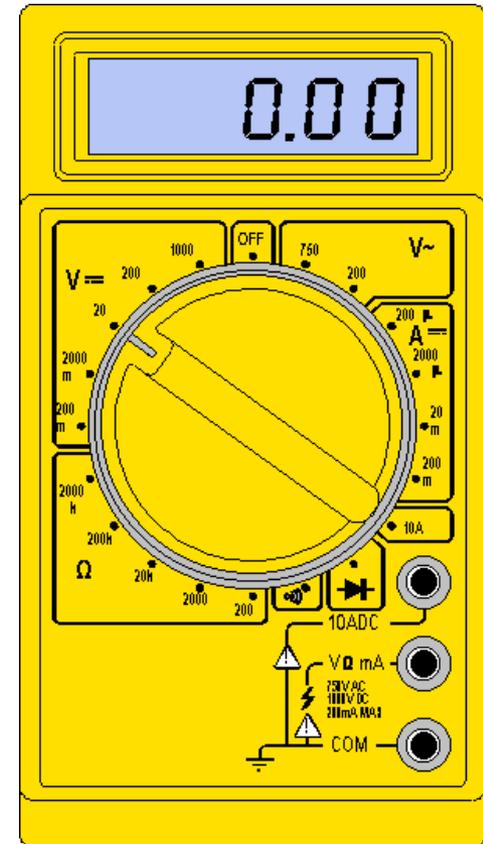
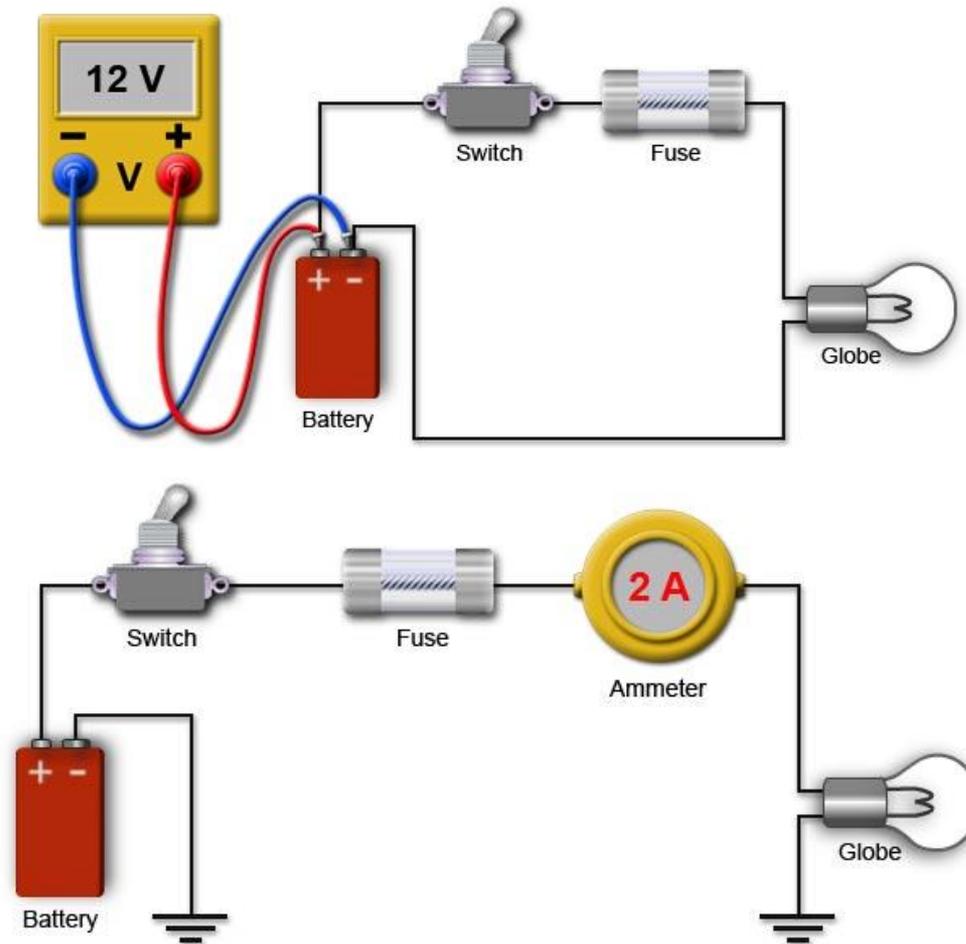
# Reference

- Design and Technology
  - James Garratt
  - 2<sup>nd</sup> Edition
  - Cambridge Edition
- **Chapter 6**
  - Control electrics and electronics

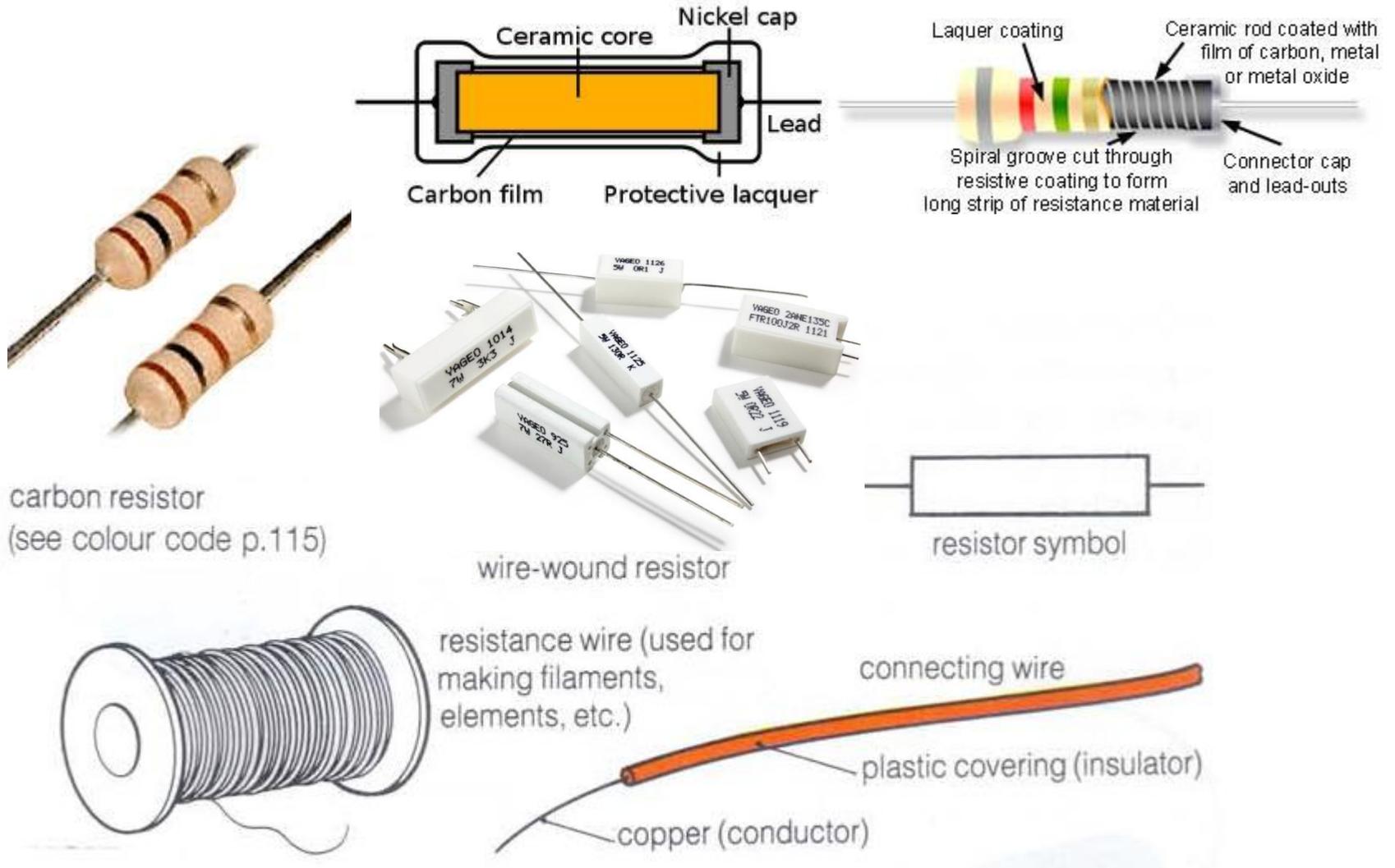


# **ELECTRONICS BASICS (REVIEW)**

# Voltage/Current Measurements



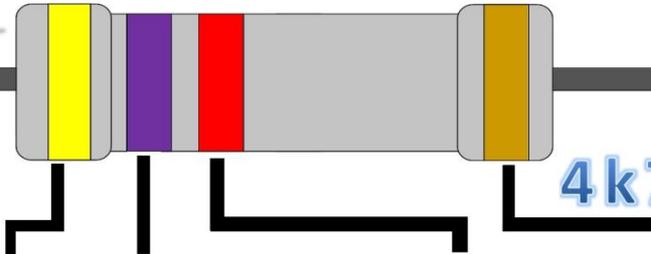
# Resistor



# Resistor Color Code

4 – Band Code

2%, 5%, 10%

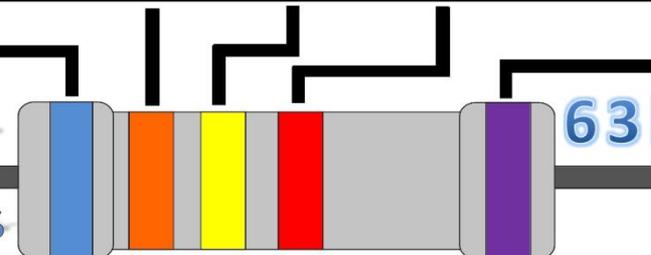


4k7Ω ±5%

Color	1 <sup>st</sup> Band	2 <sup>nd</sup> Band	3 <sup>rd</sup> Band	Multiplier	Tolerance
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1%
Red	2	2	2	100Ω	± 2%
Orange	3	3	3	1kΩ	
Yellow	4	4	4	10kΩ	
Green	5	5	5	100kΩ	± 0.5%
Blue	6	6	6	1MΩ	± 0.25%
Violet	7	7	7	10 MΩ	± 0.1%
Grey	8	8	8		± 0.05%
White	9	9	9		
Gold				0.1Ω	± 5%
Silver				0.01Ω	± 10%

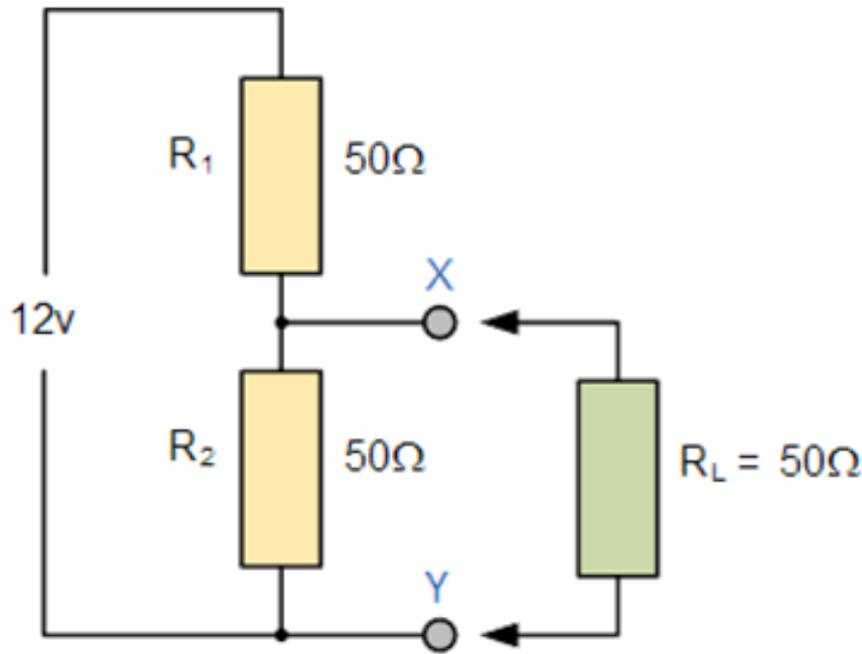
5 – Band Code

0.1%, 0.25%, 0.5%, 1%



63k4 0.1%

# Voltage Divider

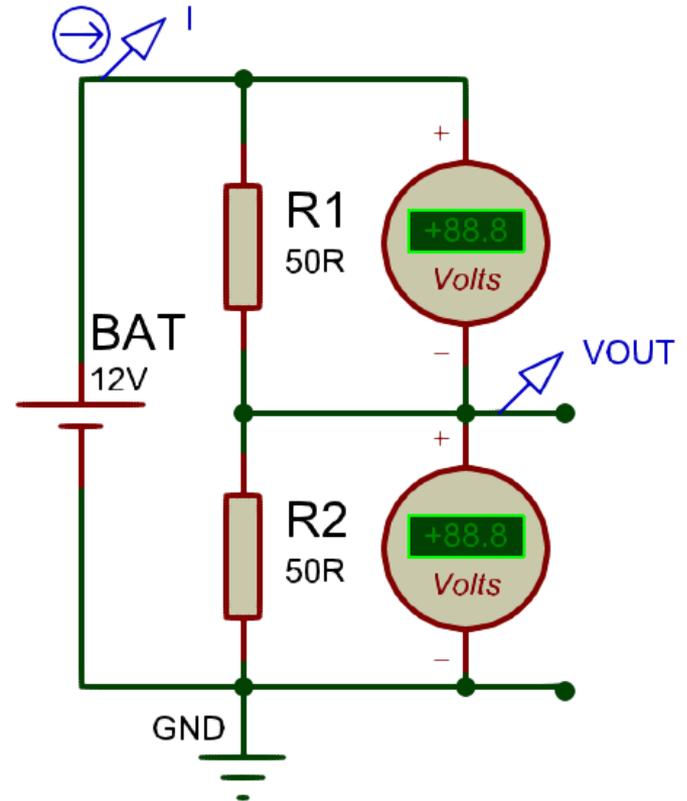


a) Without  $R_L$  connected

$$R_{X-Y} = 50\Omega$$

$$V_{out} = V_{in} \times \frac{R_2}{R_1 + R_2}$$

$$V_{out} = 12V \times \frac{50}{50 + 50} = 6.0V$$



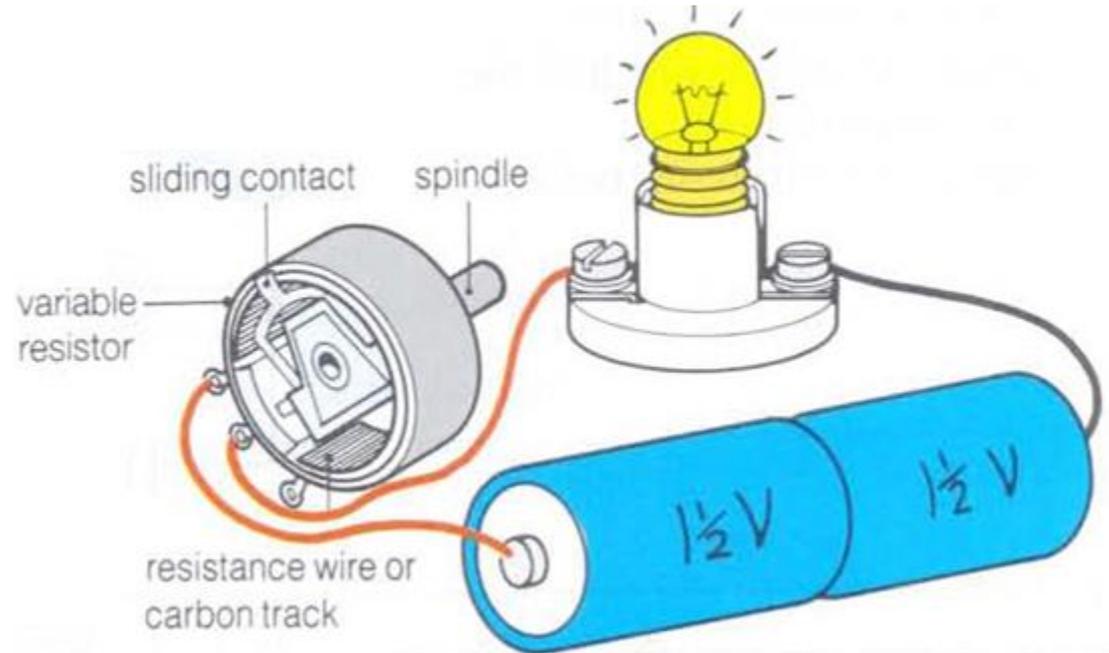
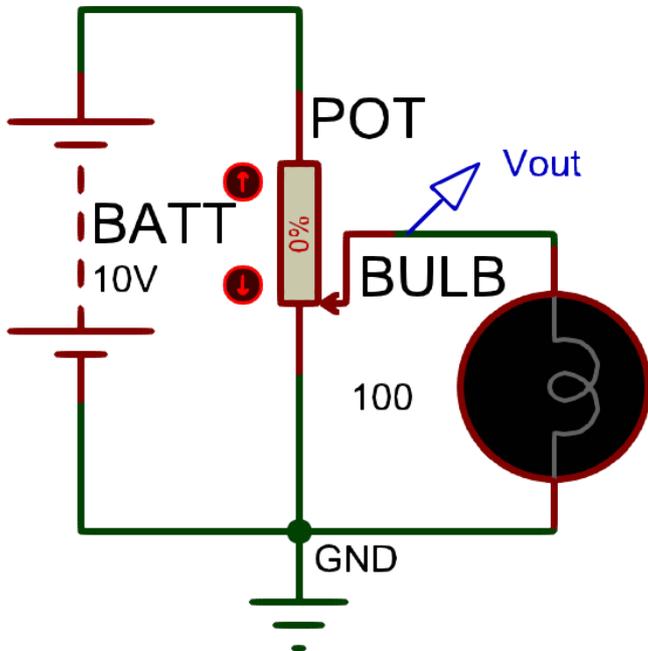
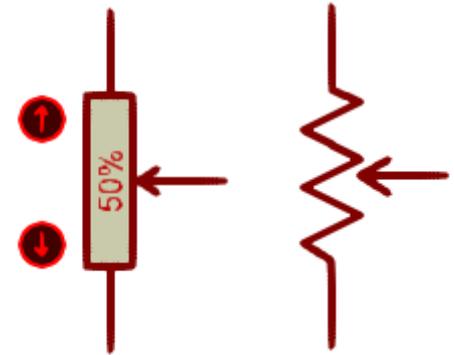
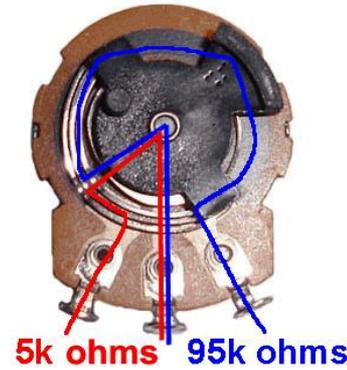
b) With  $R_L$  connected

$$R_{X-Y} = 25\Omega \text{ (Resistors in Parallel)}$$

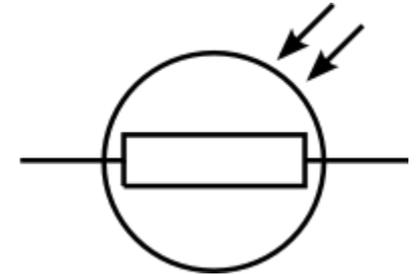
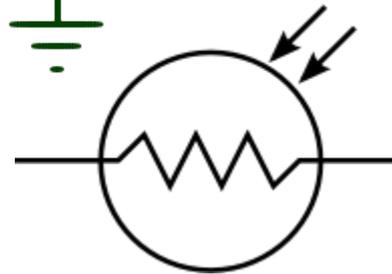
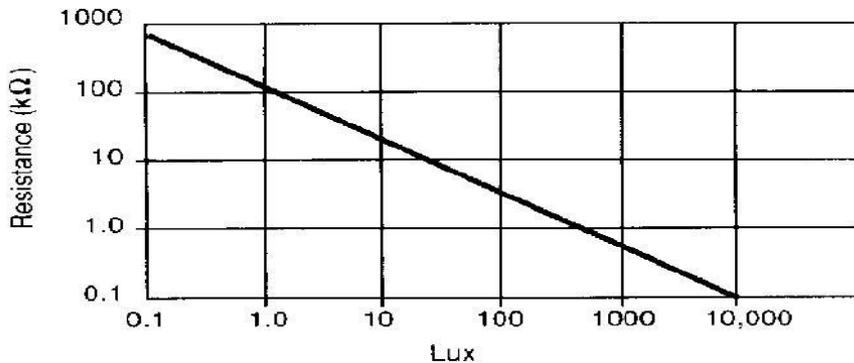
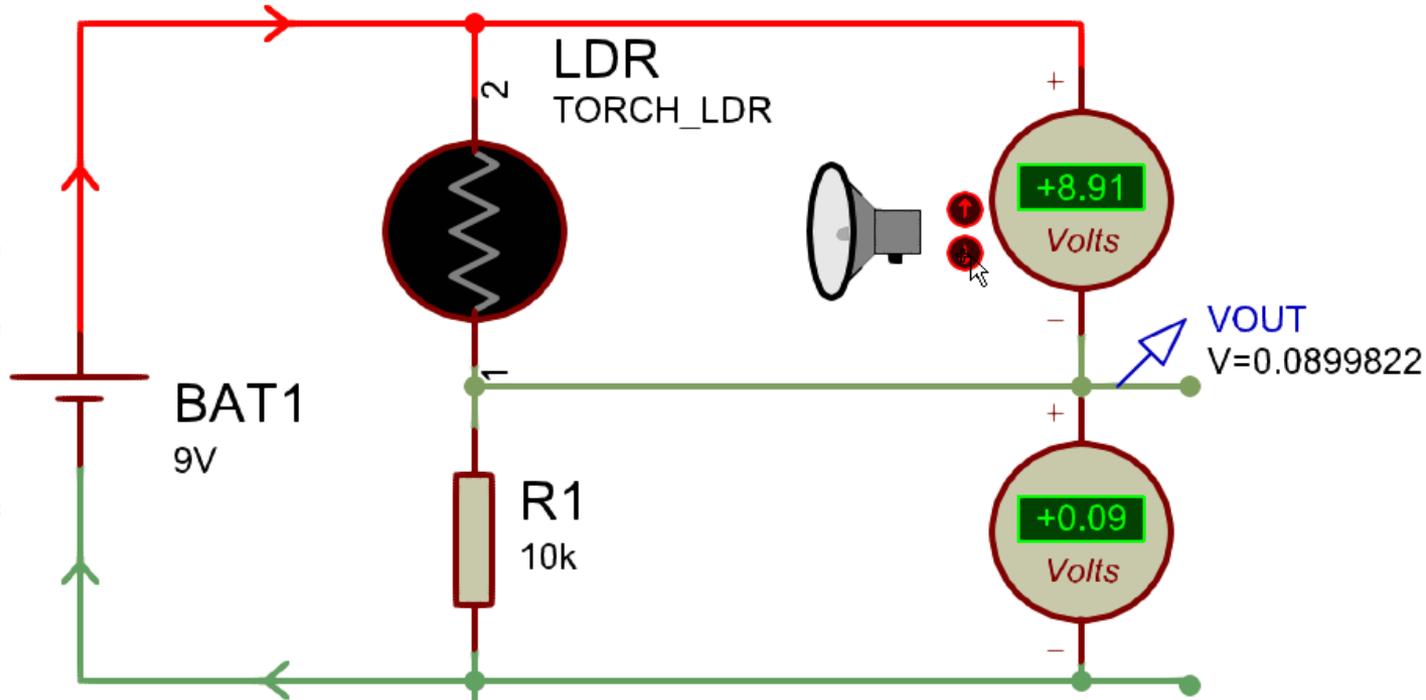
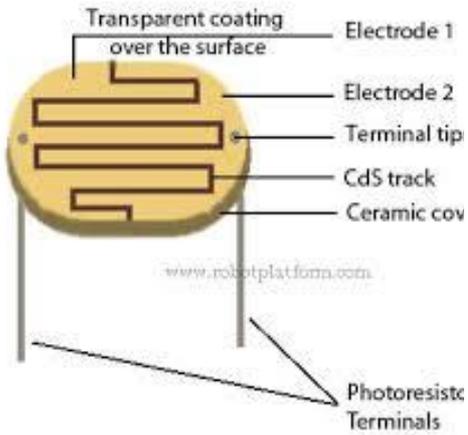
$$V_{out} = V_{in} \times \frac{R_2}{R_1 + R_2}$$

$$V_{out} = 12V \times \frac{25}{50 + 25} = 4.0V$$

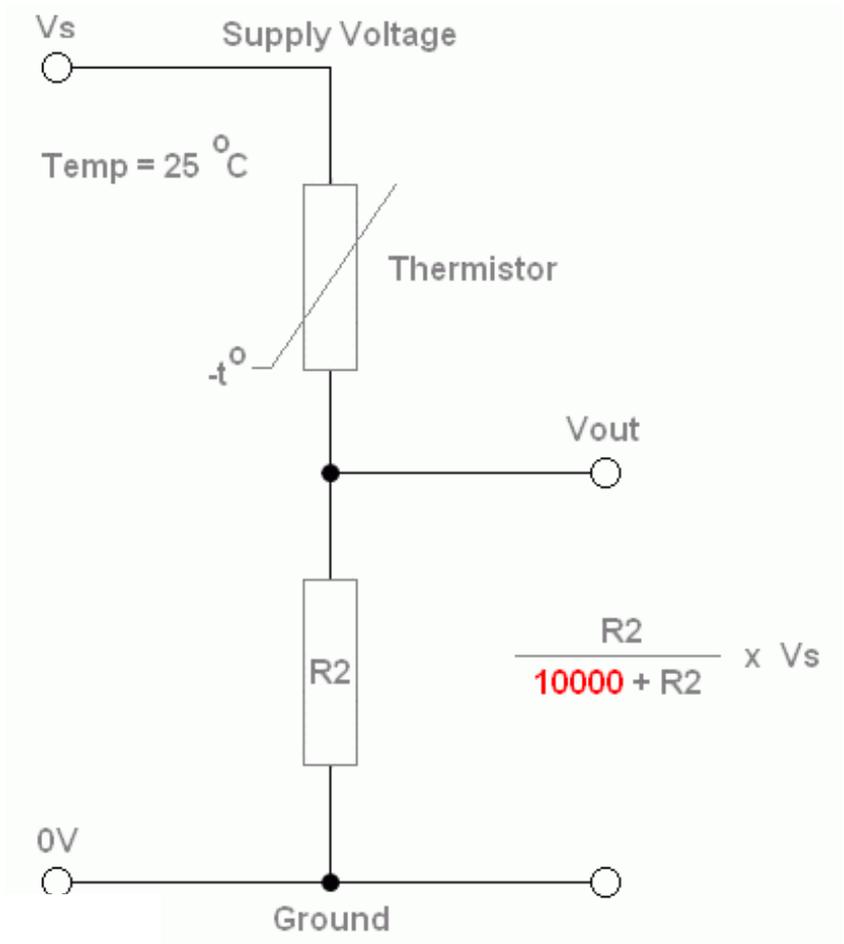
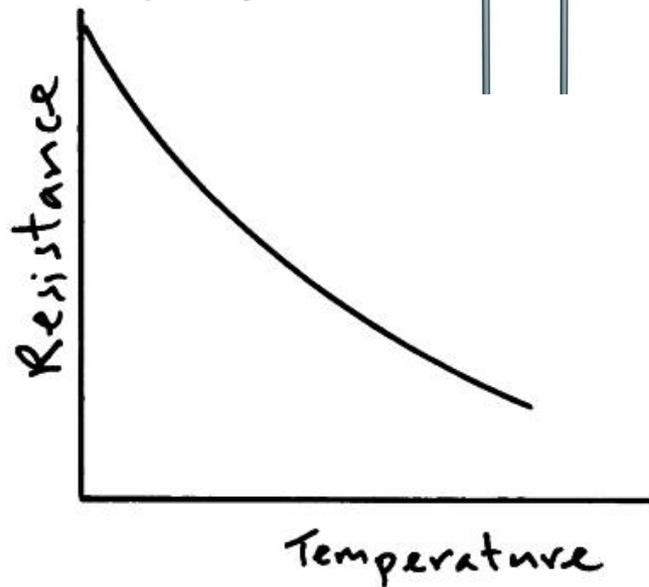
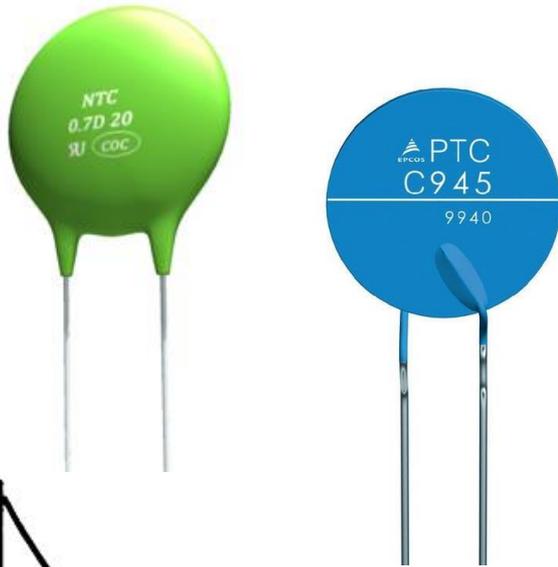
# Variable Resistor



# Light Dependent Resistor (LDR)



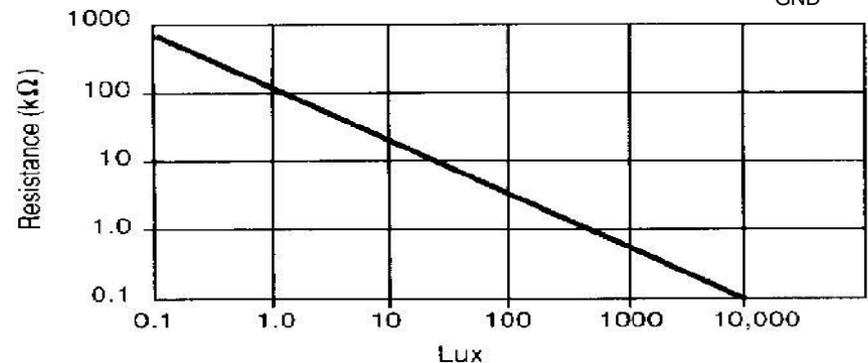
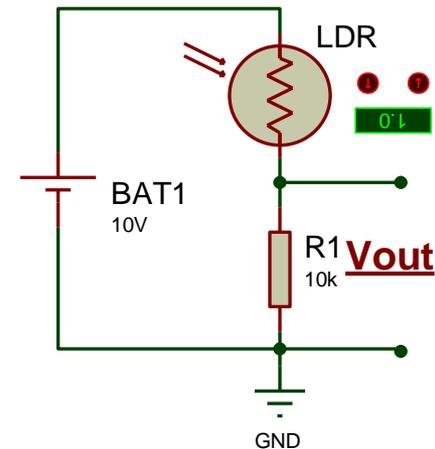
# Thermistor



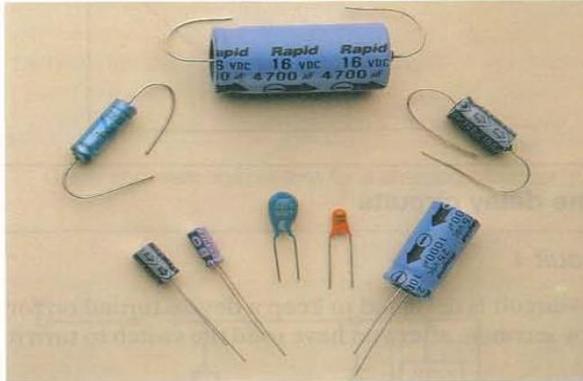
# Lab Task 1(a)

The following circuit is used in a mobile robot to detect the amount of light present in the environment. The circuit uses a LDR as light sensor. Answer the following questions using the information provided to you.

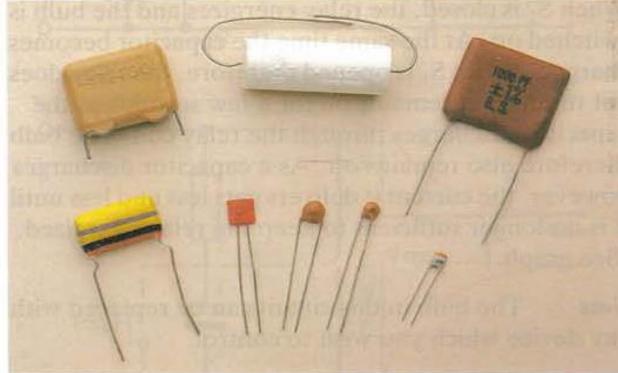
- Sketch the graph of  $V_{out}$  against intensity?
- Sketch the graph of  $V_{out}$  against intensity if the position of resistor R and LDR swapped?
- Redesign the value of the resistor such that  $V_{out} = 1V$  at a light intensity of 1 Lux?



# Capacitor



Polarized capacitors



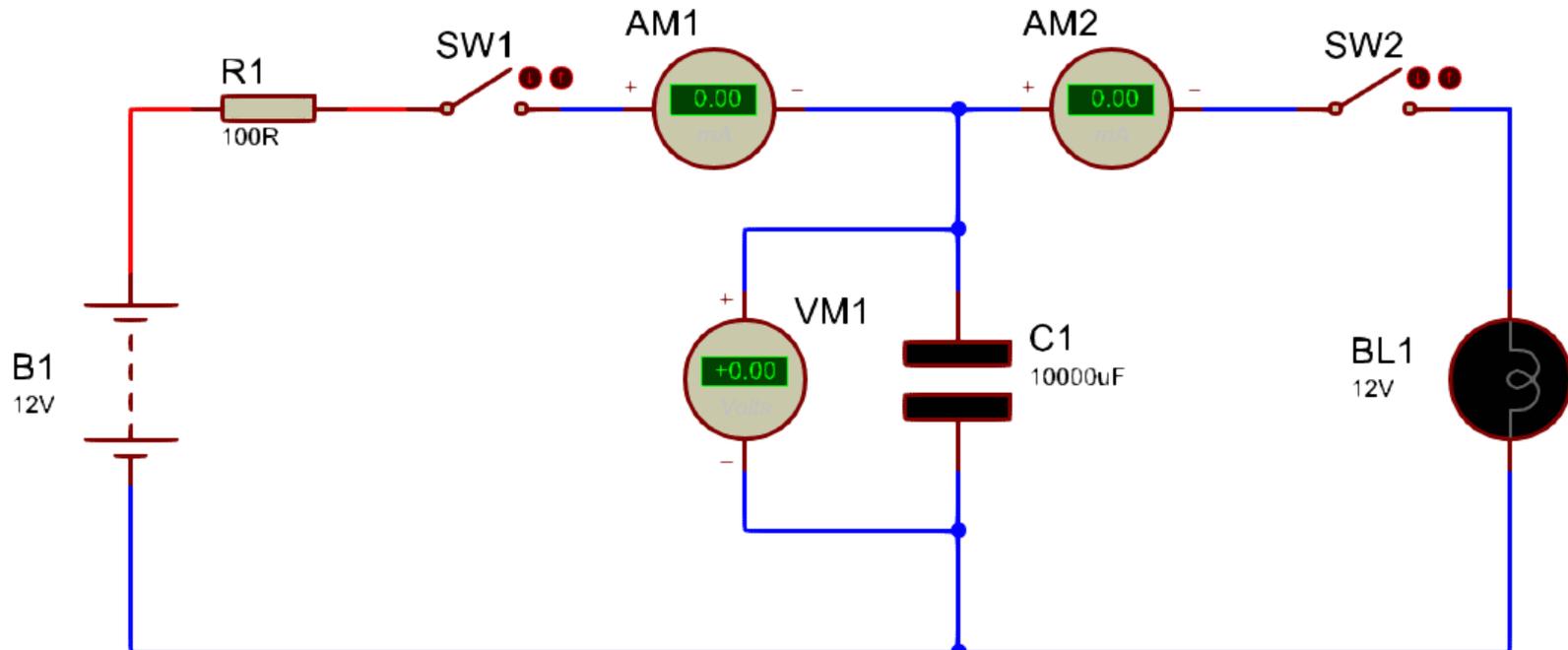
Non-polarized capacitors



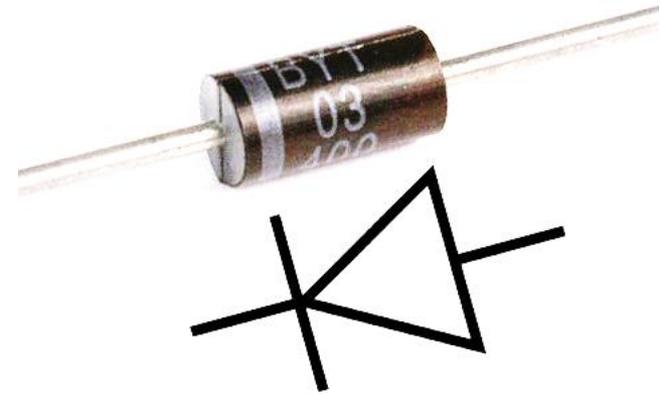
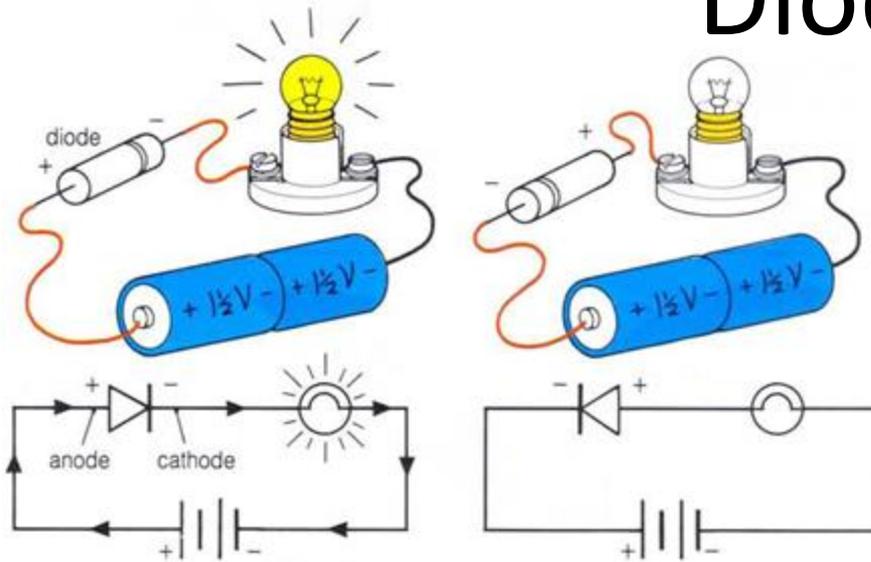
symbol for polarized capacitor



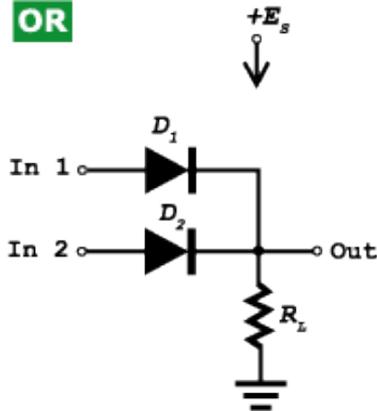
symbol for non-polarized capacitor



# Diode



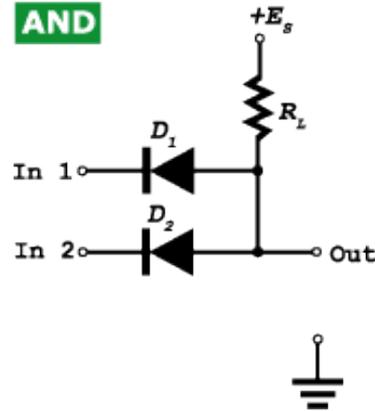
**OR**



In 1	In 2	Out
0	0	0
0	1	1
1	0	1
1	1	1

0 - 0V  
1 - Es

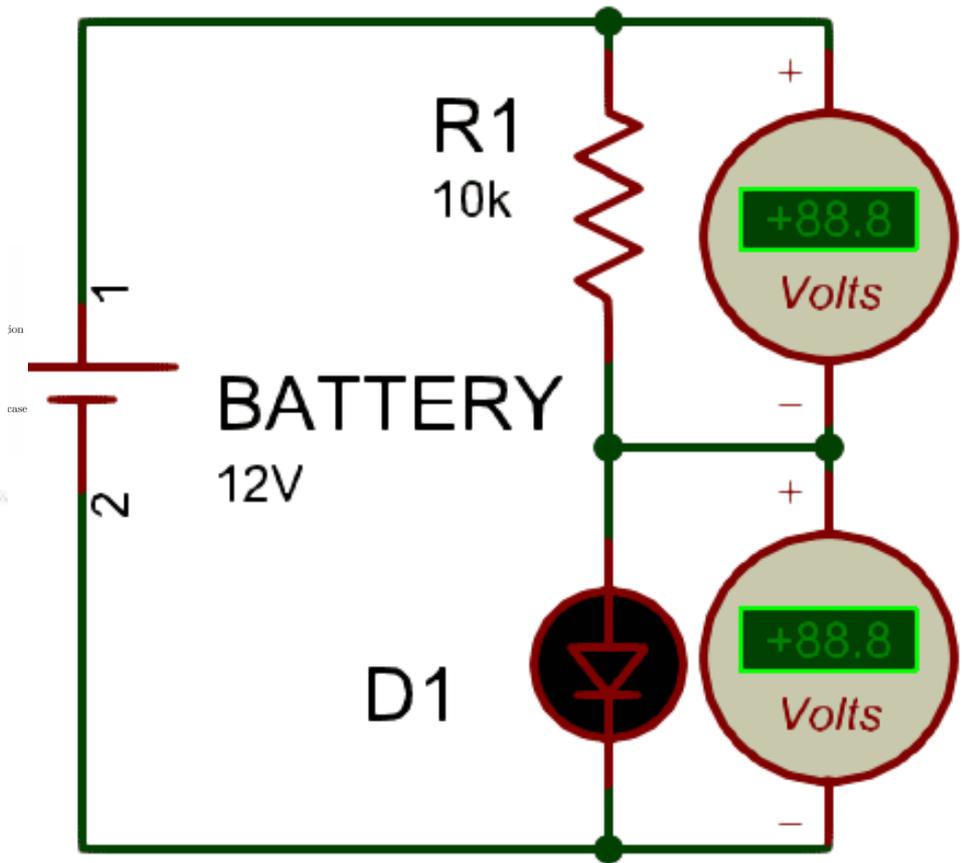
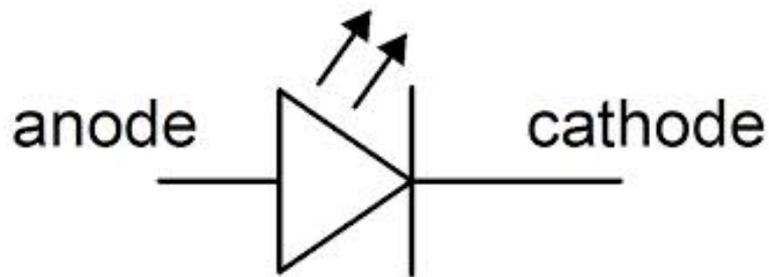
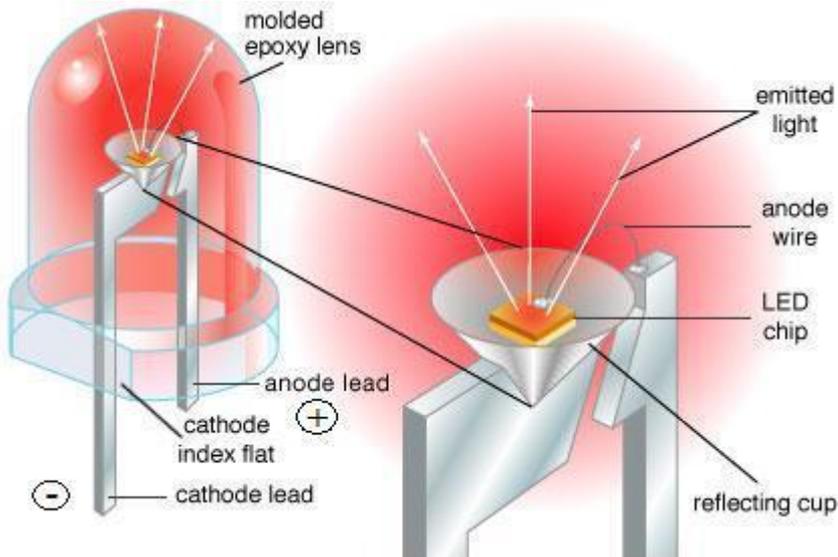
**AND**



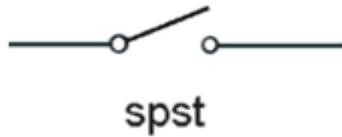
In 1	In 2	Out
0	0	0
0	1	0
1	0	0
1	1	1

Can we use a diode as voltage divider?

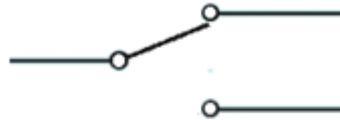
# Light Emitting Diode (LED)



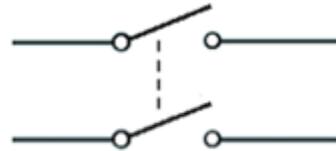
# Switches



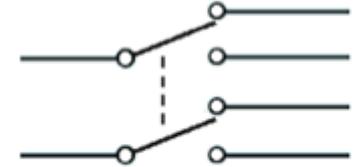
spst



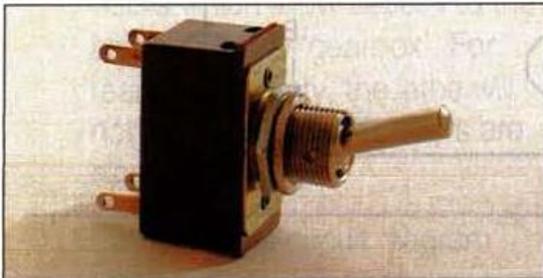
spdt



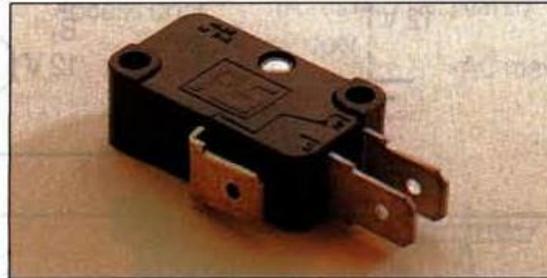
dpst



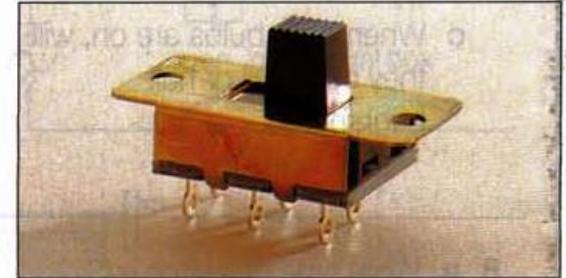
dpdt



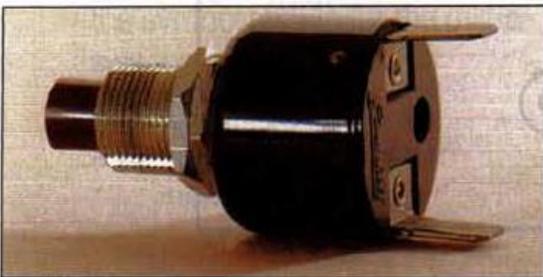
Toggle switch.



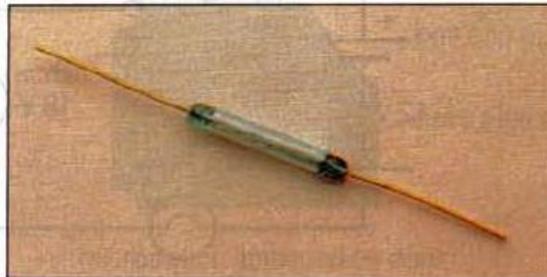
Microswitch



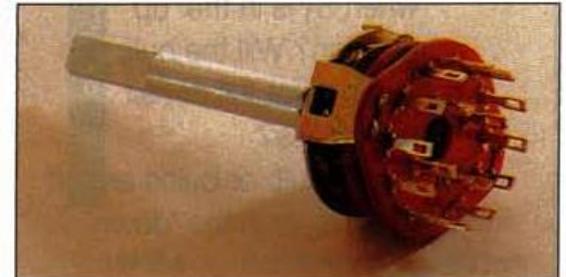
Slide switch



Push button switch



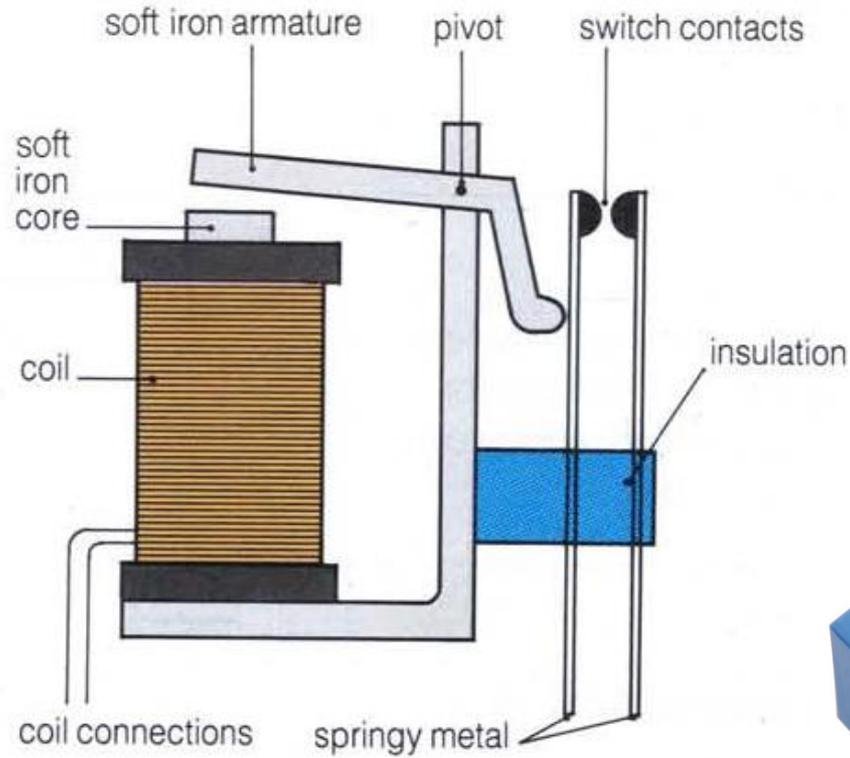
Reed switch



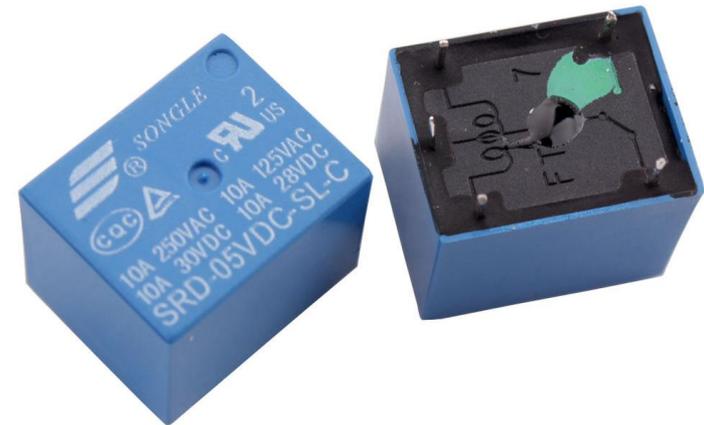
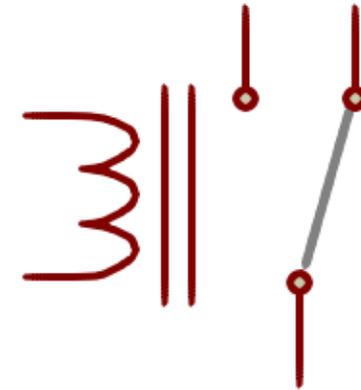
Rotary switch



# Relay

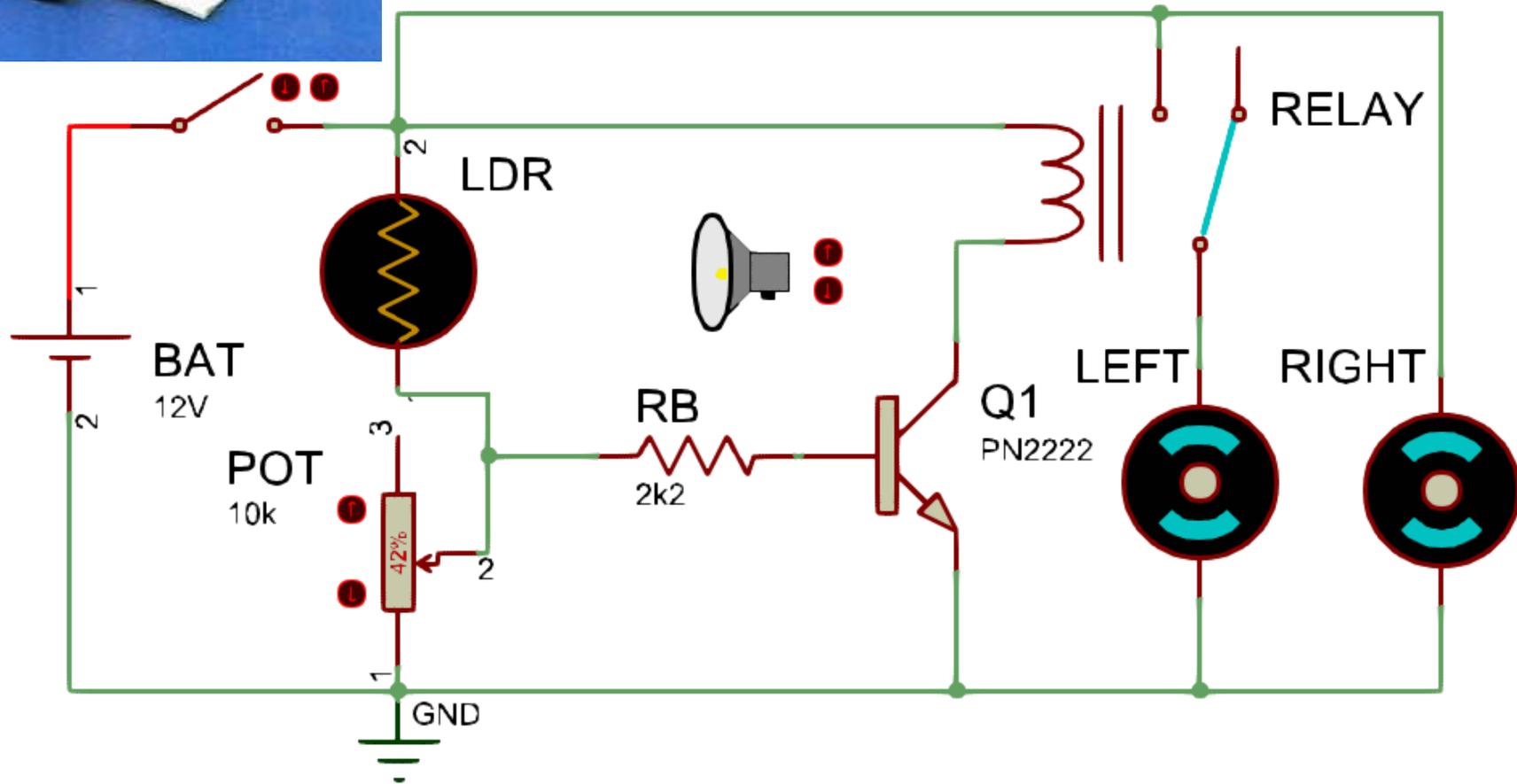
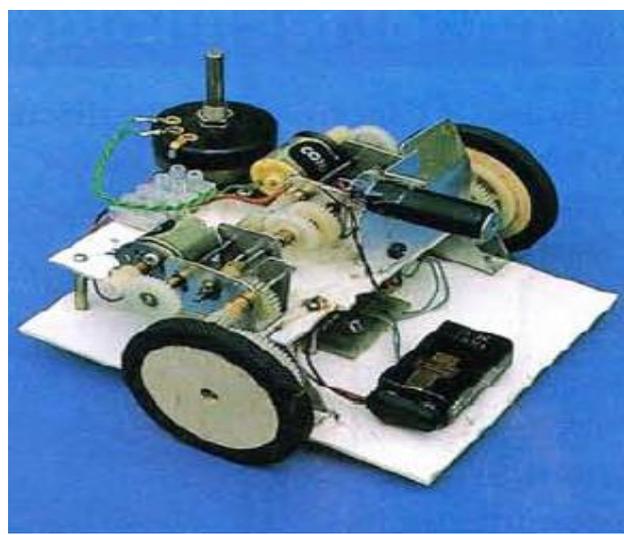


Construction of simple relay



**What is the advantage of a relay over a transistor?**

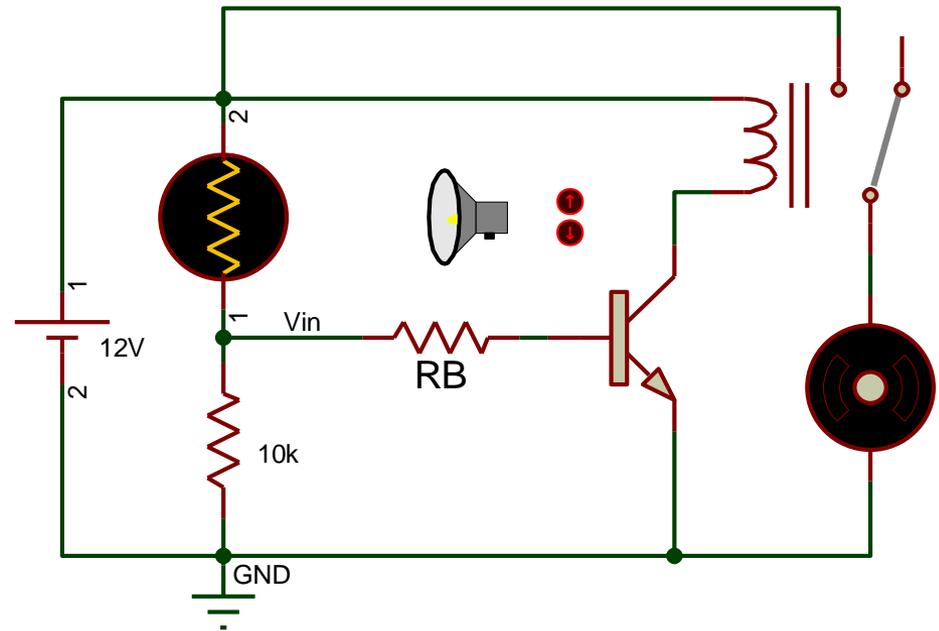
# Relay Application



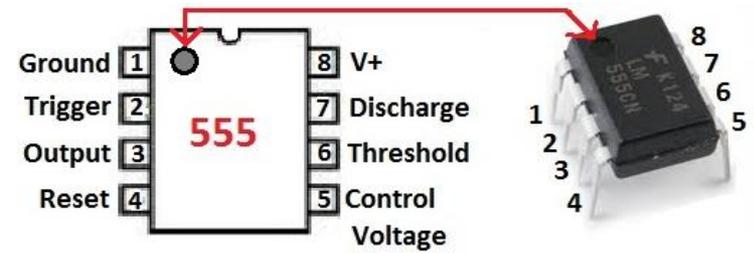
# Lab Task 1(b)

The relay in the circuit turns on when  $50\text{mA}$  of current flows through its coil. The transistor used in the circuit has  $\beta = 100$  and  $V_b = 0.7\text{V}$

- How much base current is required to turn on the transistor?
- At which voltage ( $V_{in}$ ) the motor will be turned on, considering  $R_B = 2\text{k}\Omega$ ?



# Timer 555



$$f = \frac{1.44}{(R_1 + 2R_2)C_1}$$

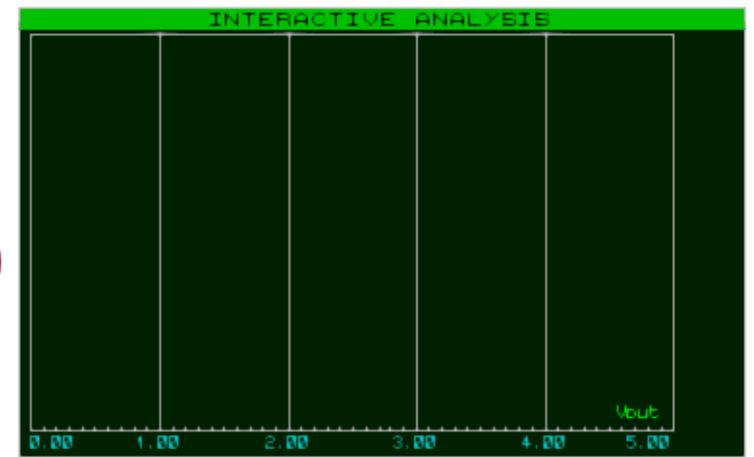
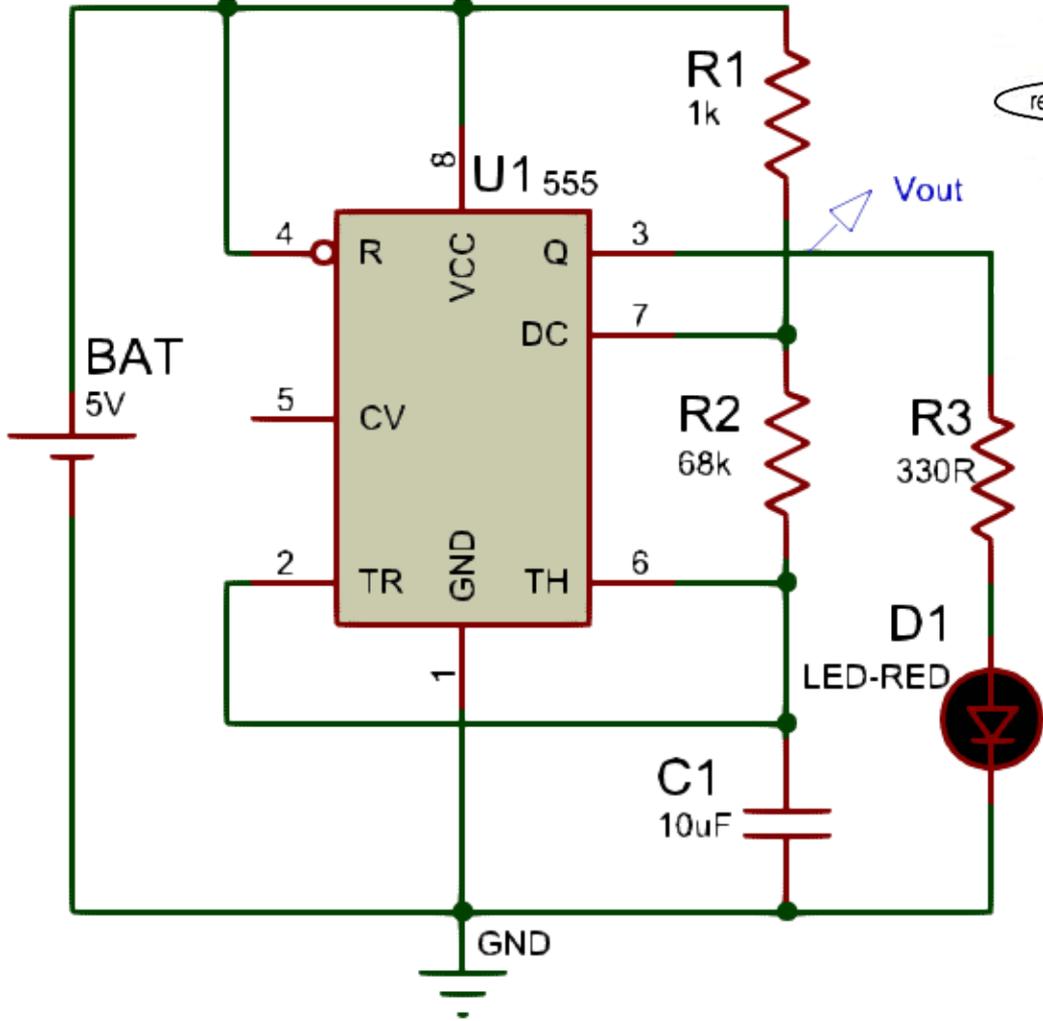
resistance in ohms      capacitance in farads

For above example:

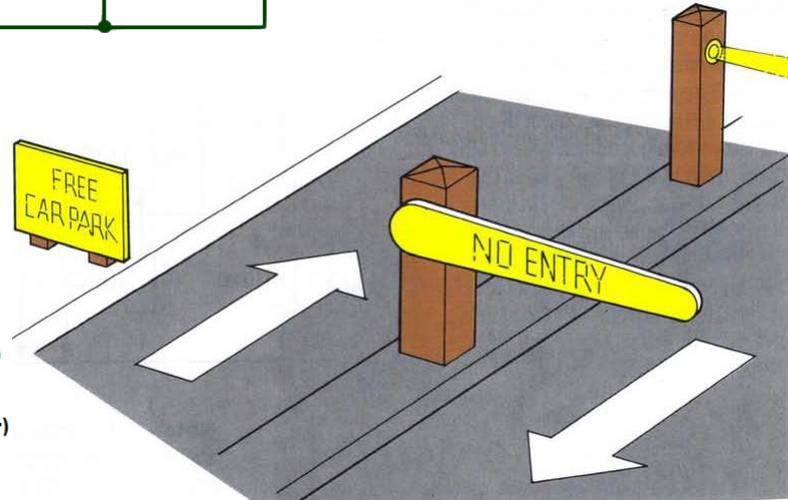
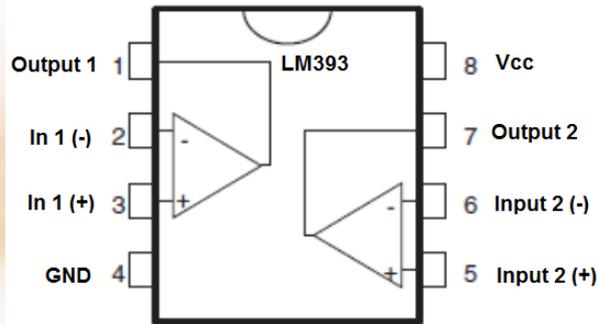
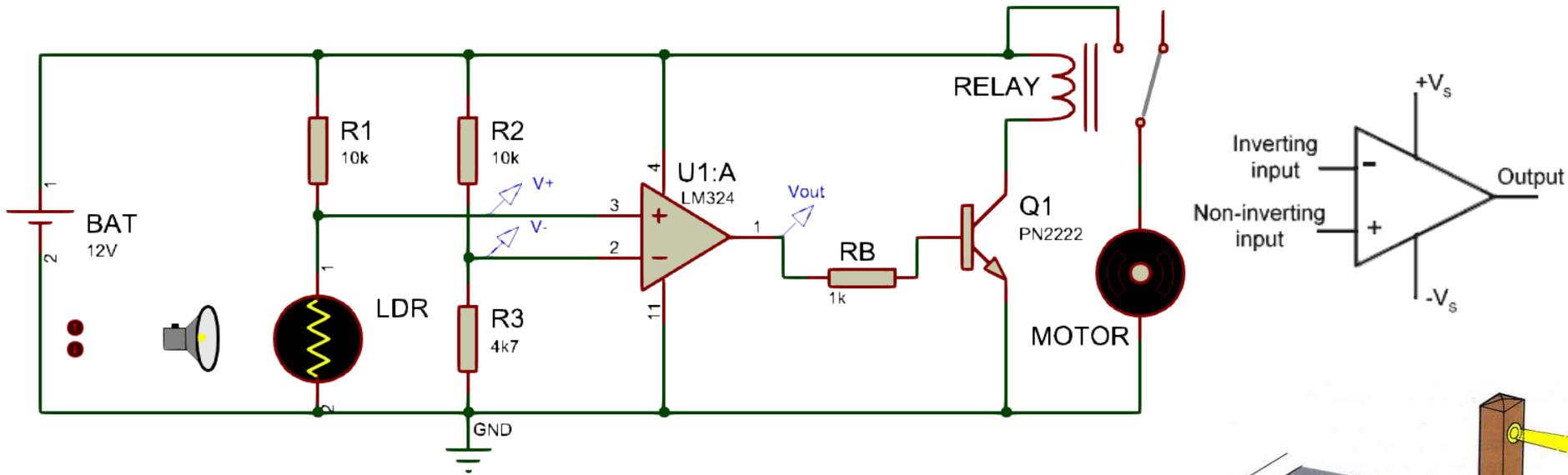
$$f = \frac{1.44}{(1000 + 2 \times 68000) \times 0.00001}$$

$$f = \frac{1.44}{1.37}$$

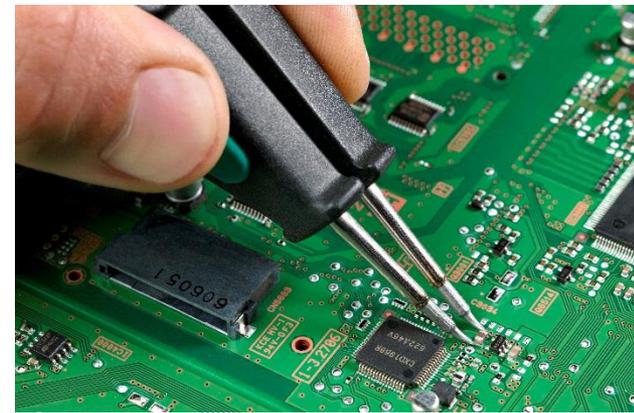
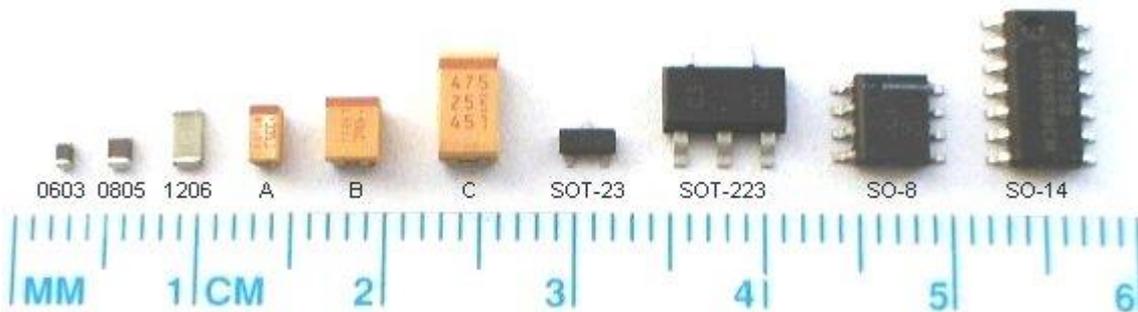
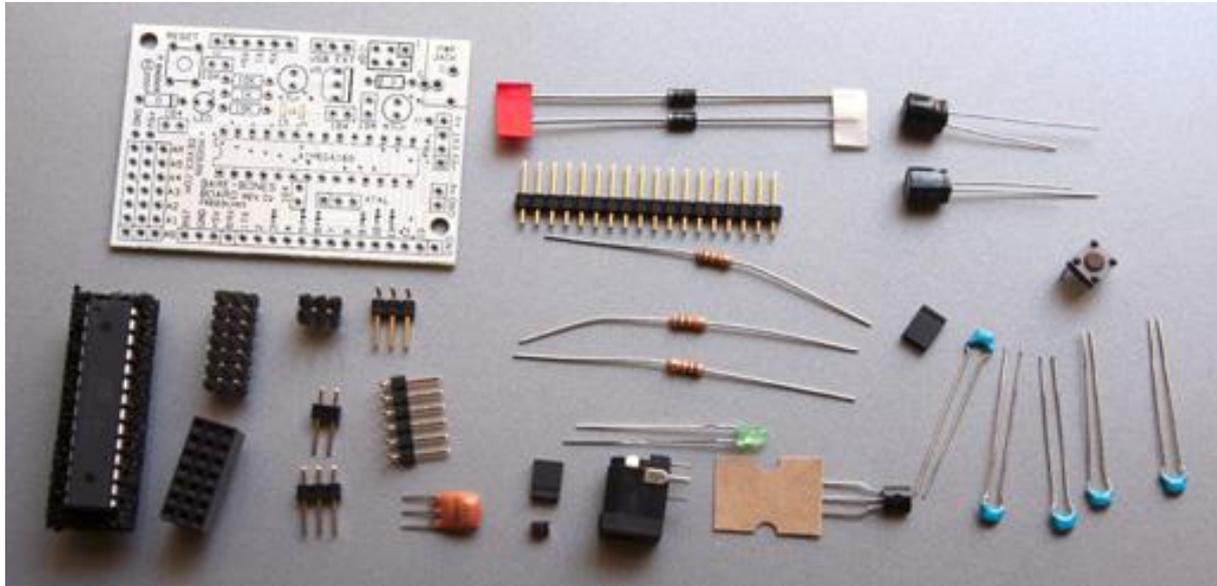
$$f = 1.05 \text{ Hz}$$



# Operational Amplifier (Op-Amp)



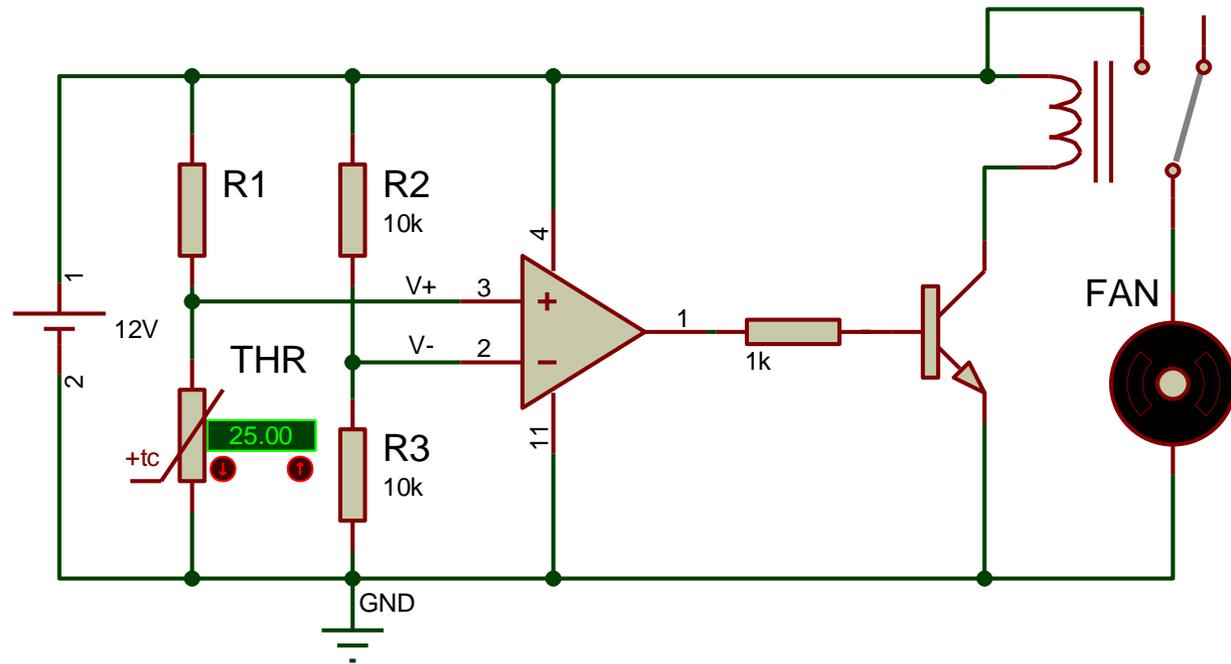
# Through-Hole/SMD Components



# Lab Task 1(c)

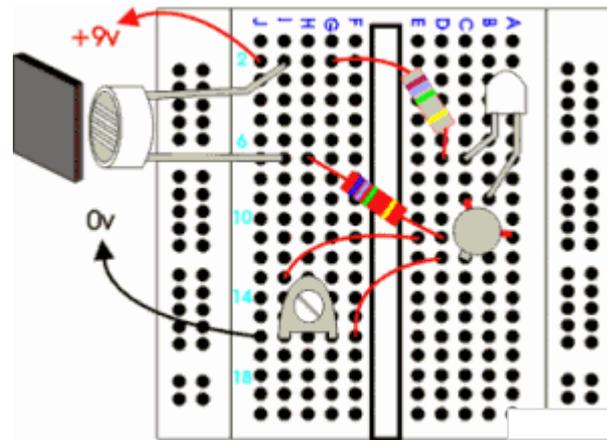
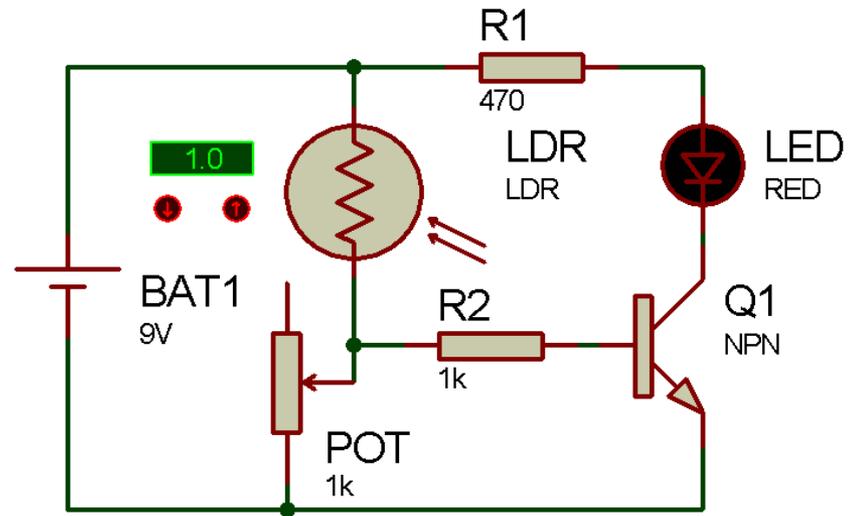
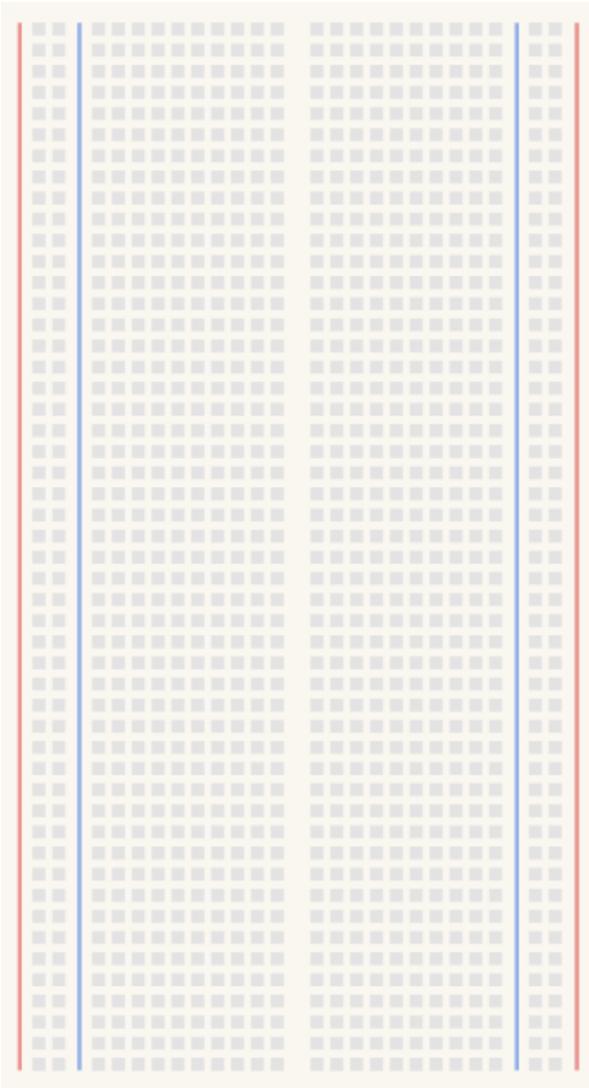
The following circuit uses thermistor and an op-amp to control the temperature of a room. The fan is required to maintain the room temperature at  $25^{\circ}\text{C}$ .

- At what voltage ( $V_{+}$ ) the fan turns on?
- What is the value of resistance R1 required to **just** turn on the fan. The resistance of thermistor ( $RT1$ ) is  $10\text{K}\Omega$  at the temperature of  $25^{\circ}\text{C}$ ?

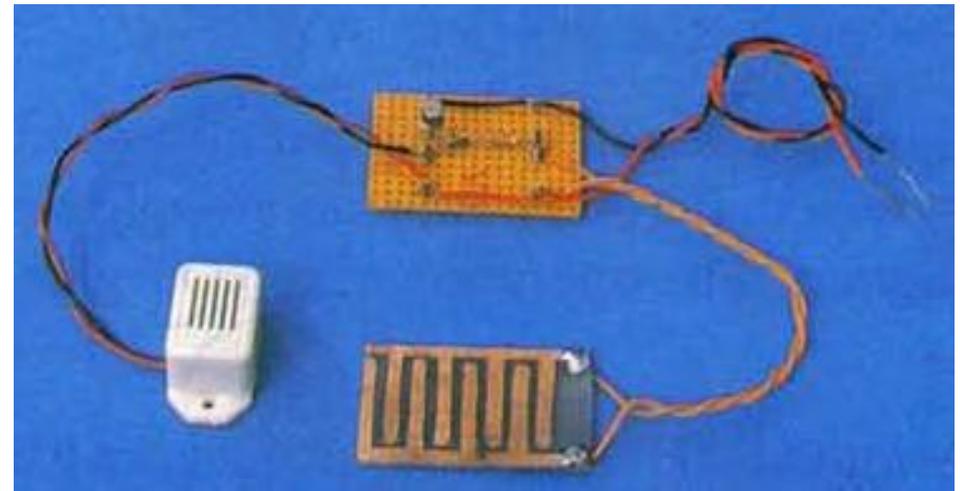
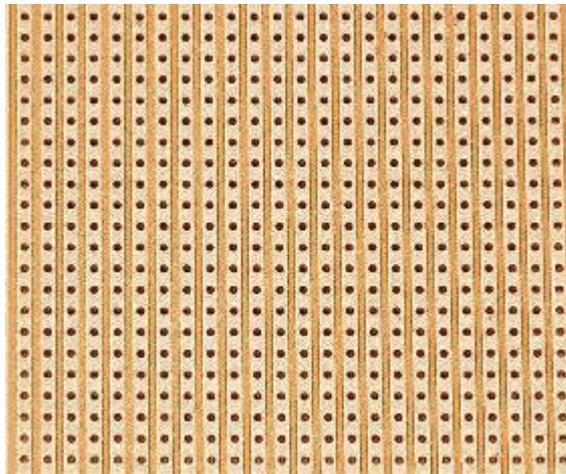
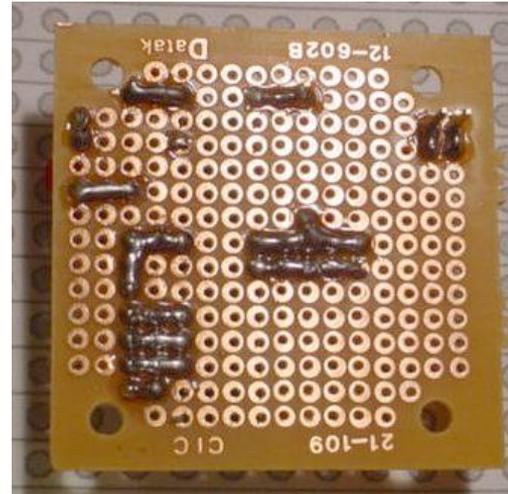
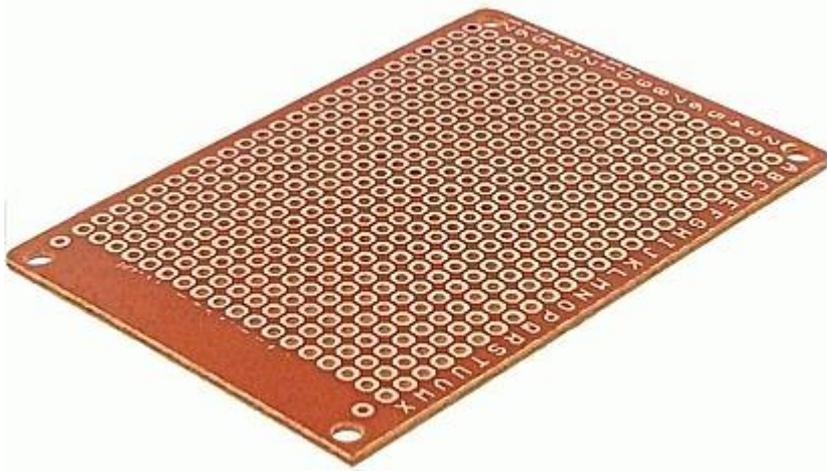


# **PCB PROTOTYPING CONVENTIONAL**

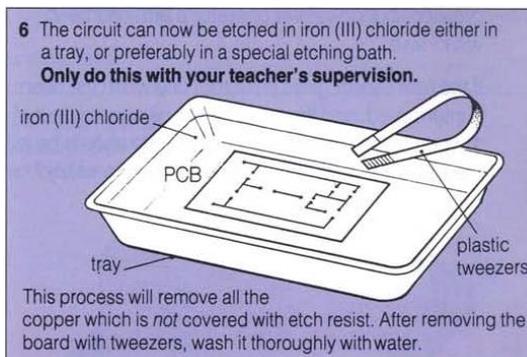
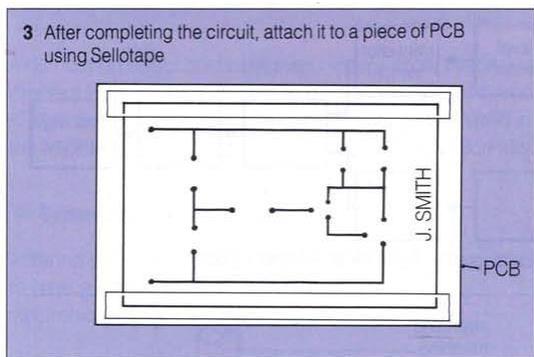
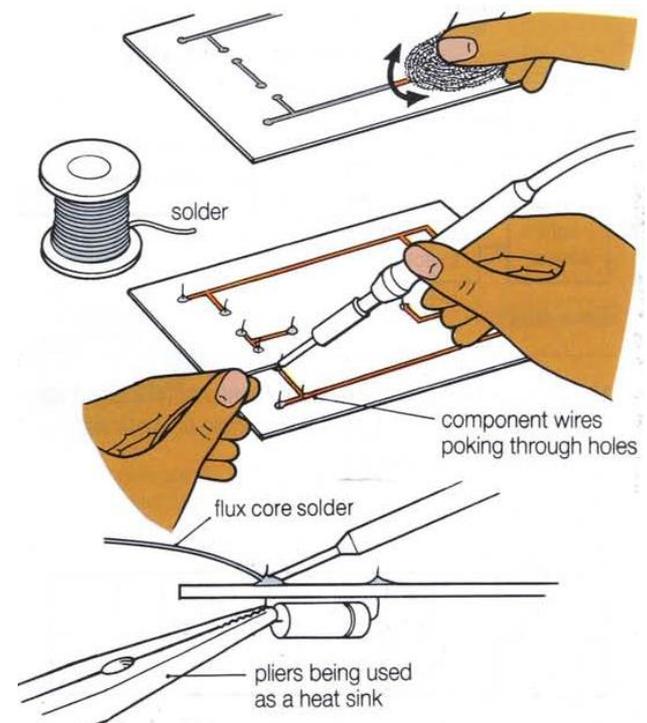
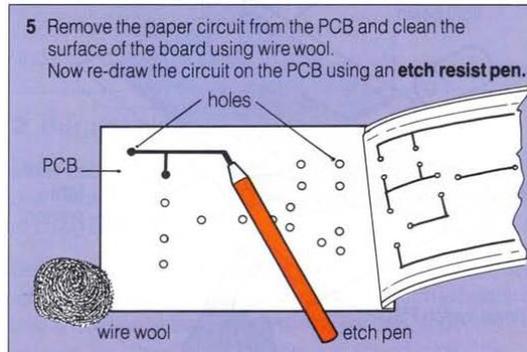
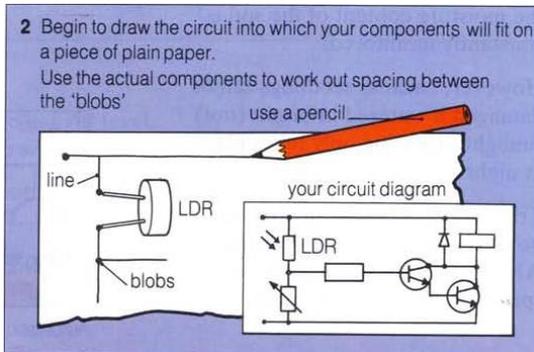
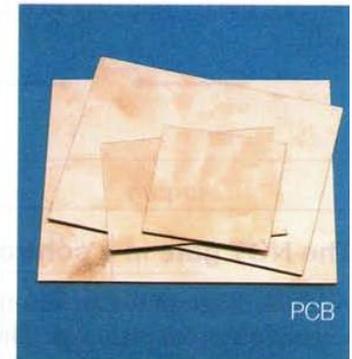
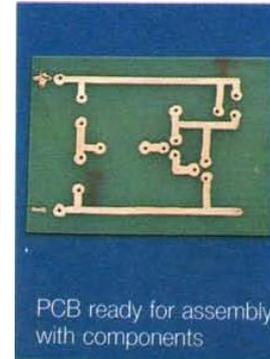
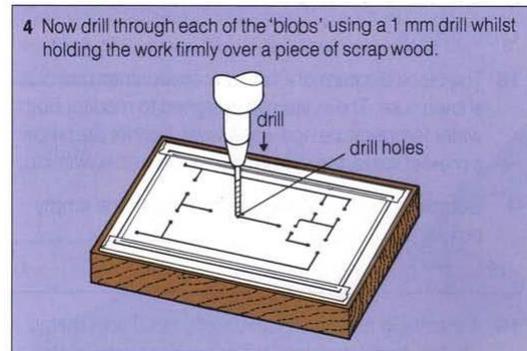
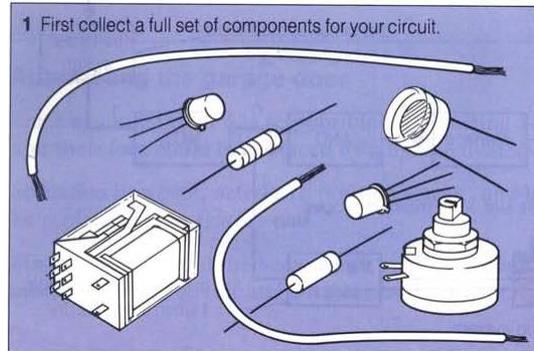
# Bread Board



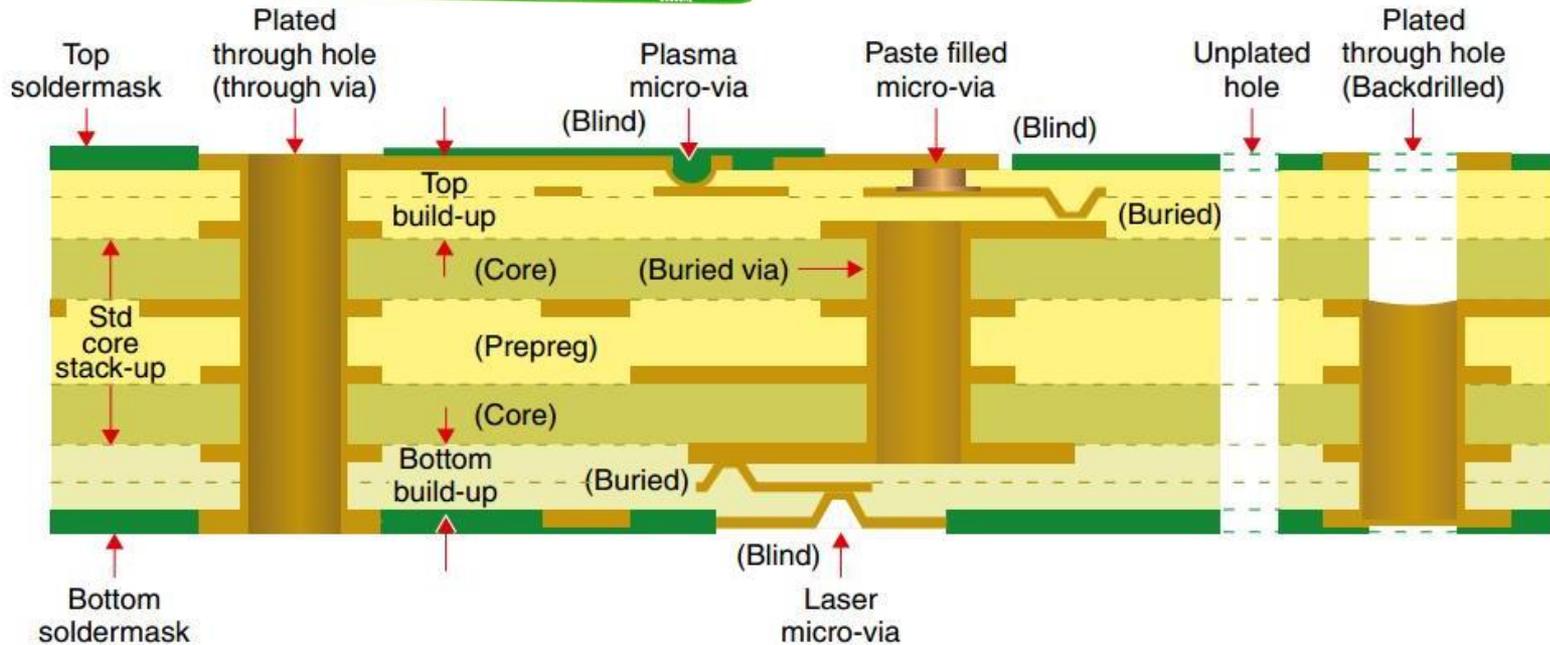
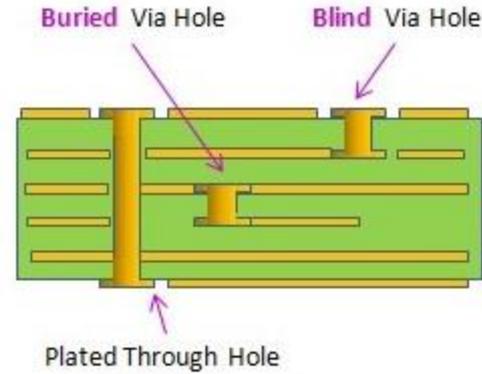
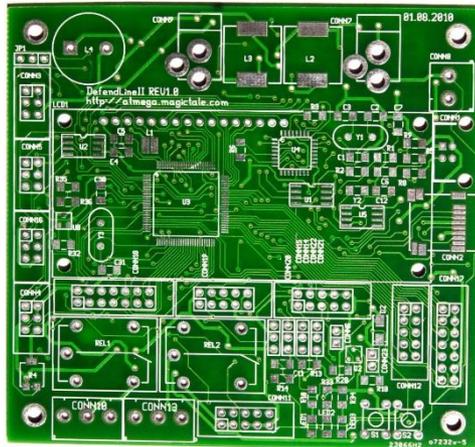
# Vero Board (Matrix/Strip)



# Single Layer PCB Prototyping Workflow



# PCB Nomenclature

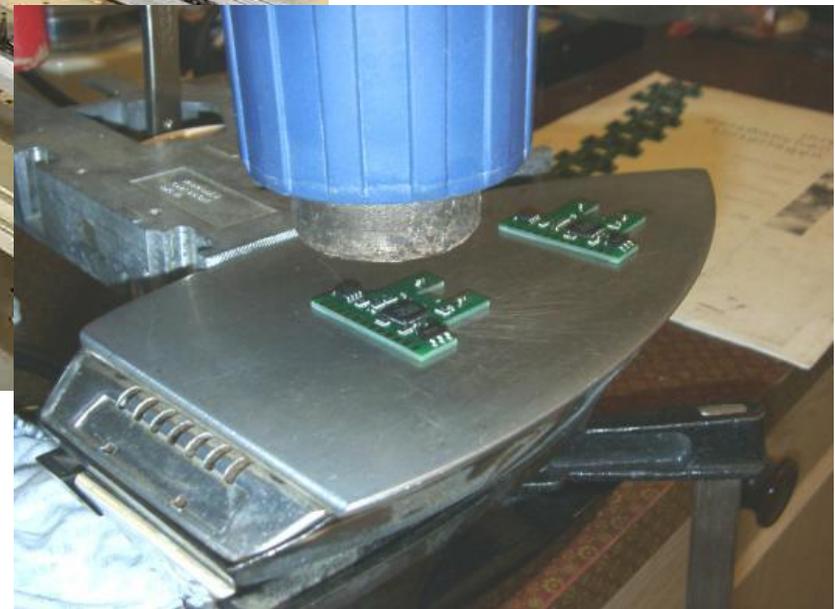


# SMD Technology: Pick and Place Machine



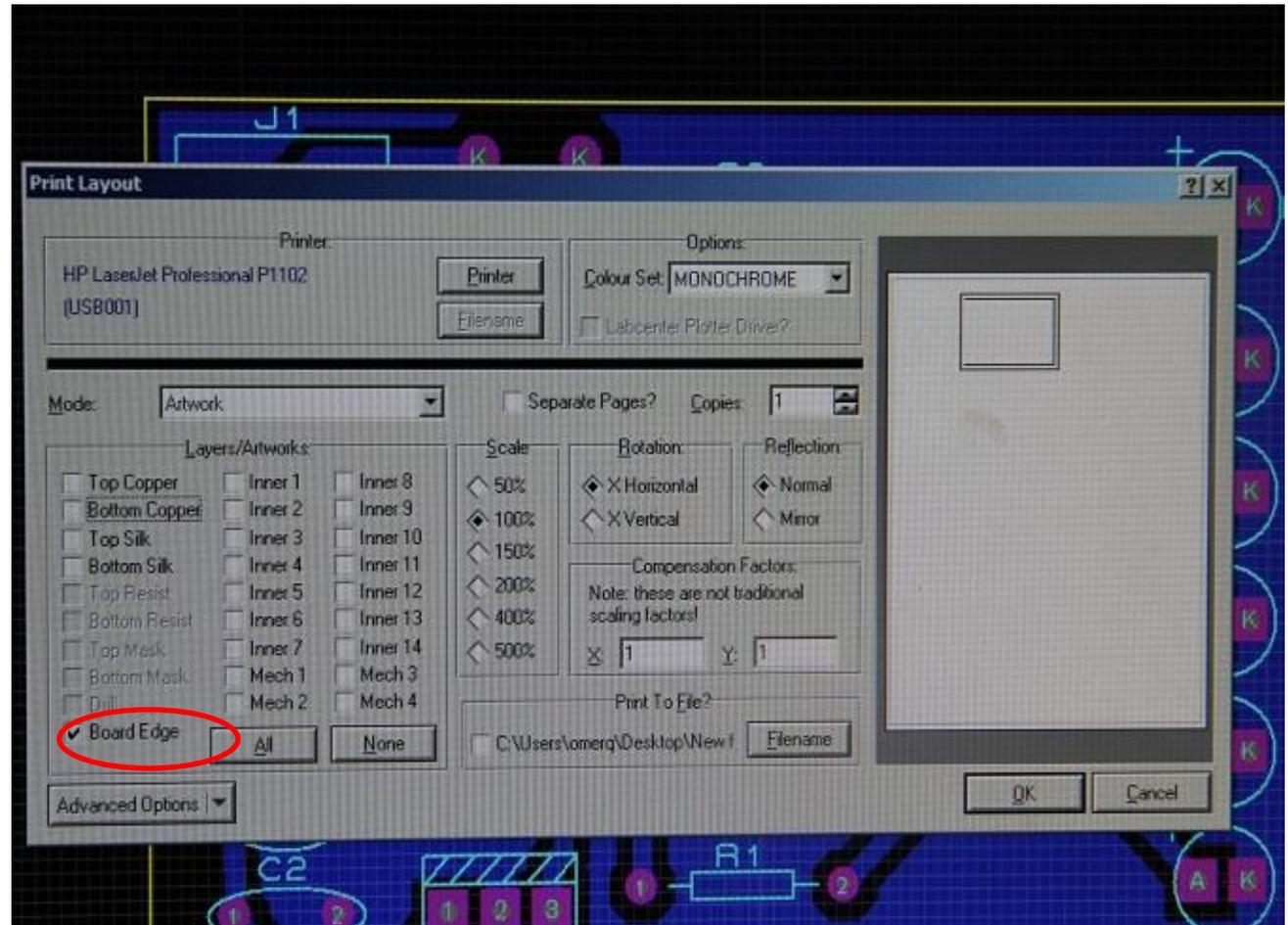
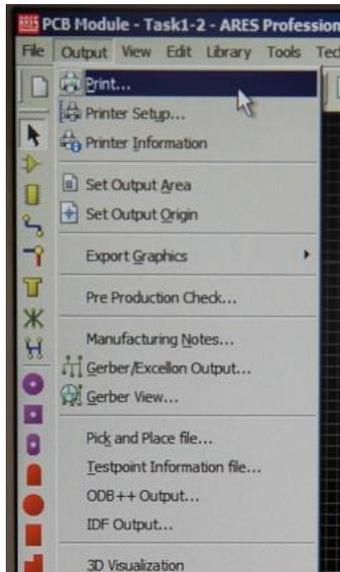
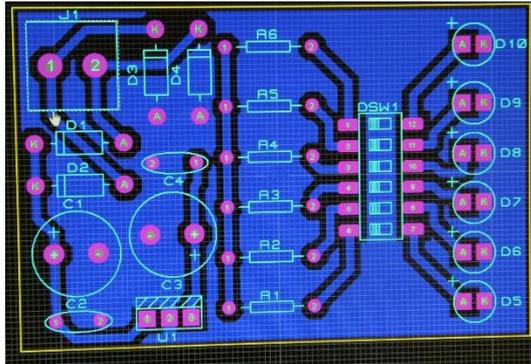
[tonny@neodentech.com](mailto:tonny@neodentech.com)

# SMD Technology: Reflow Oven



# CONVENTIONAL PCB PROTOTYPING

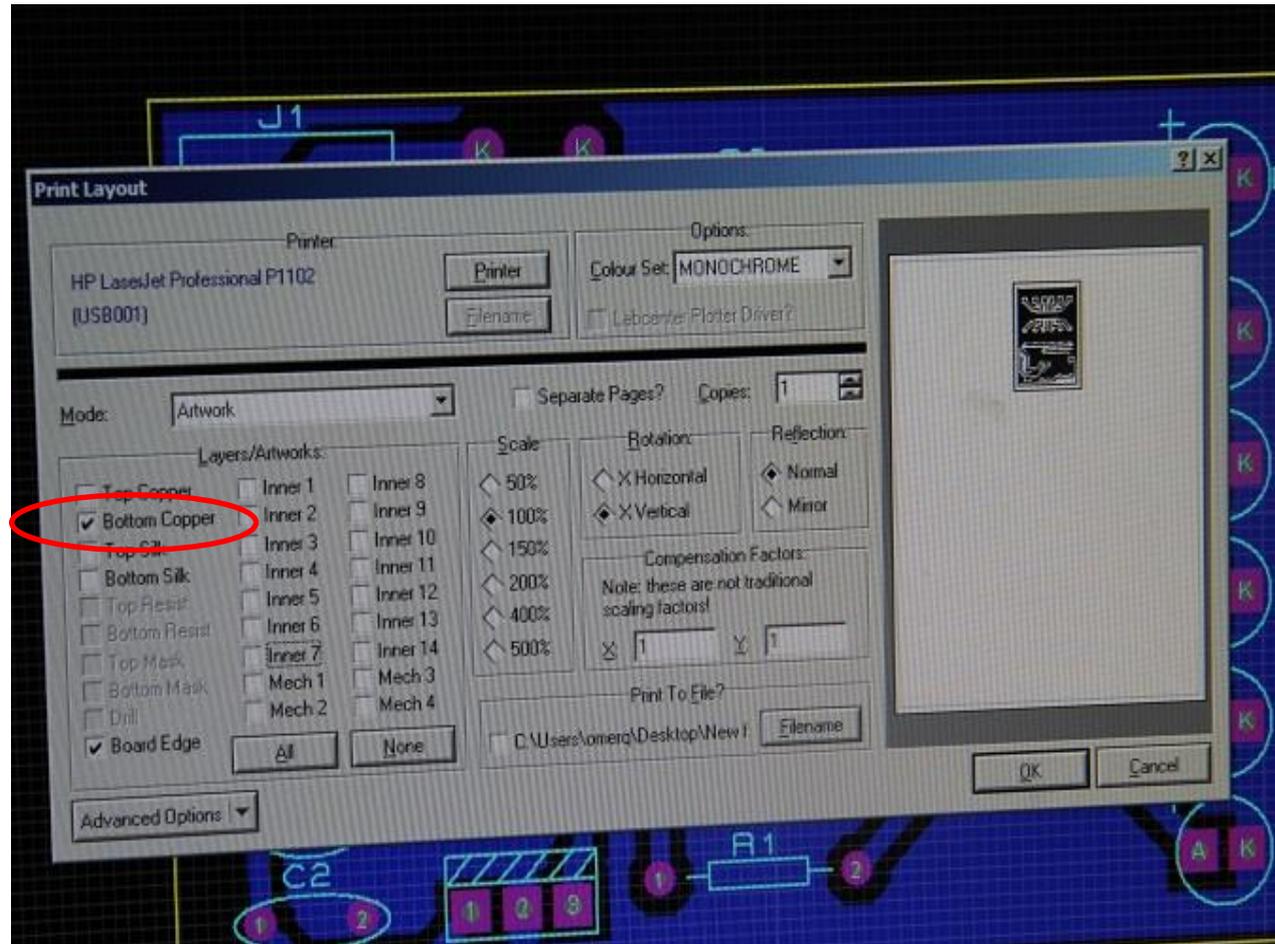
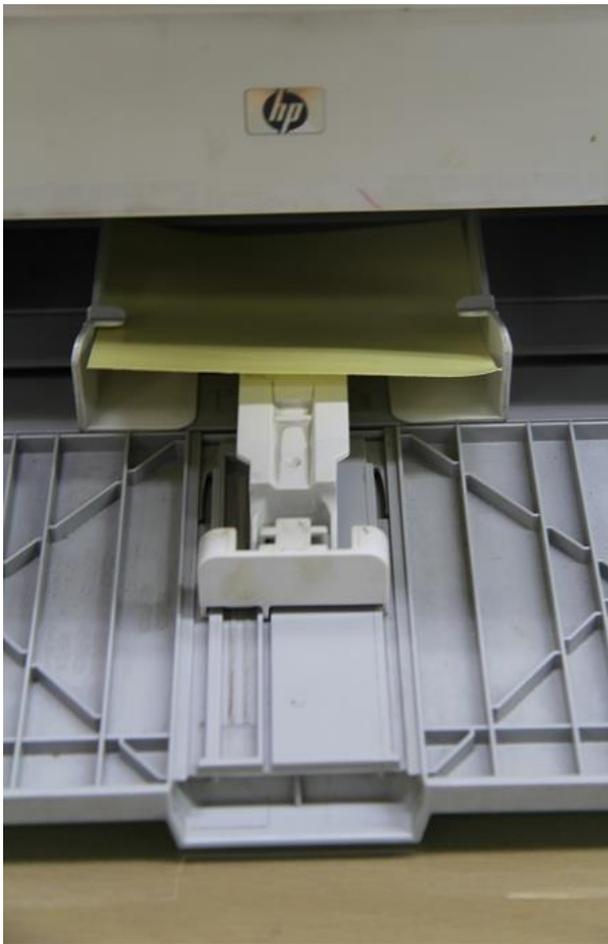
# Print Outline for PCB Cutting



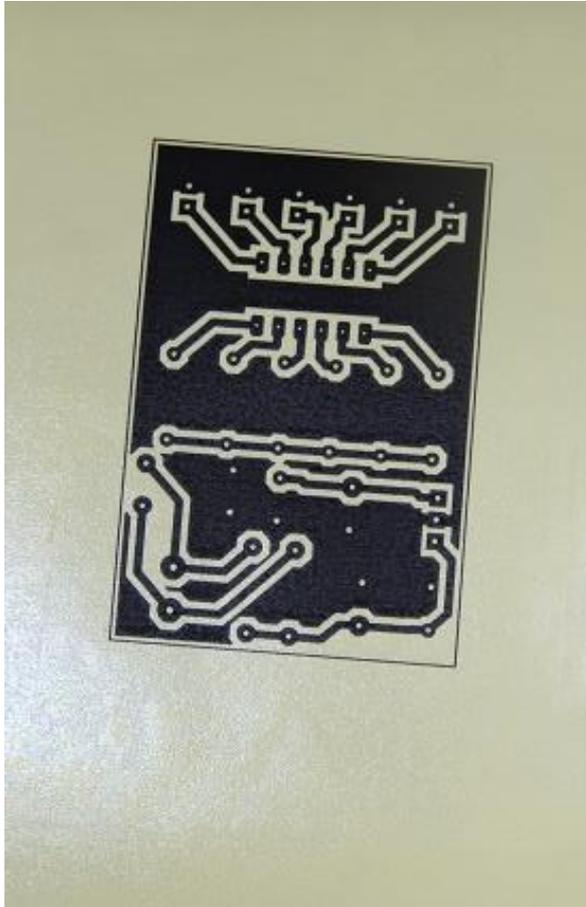
# Cut Butter Paper / Peel Off Sticker Side



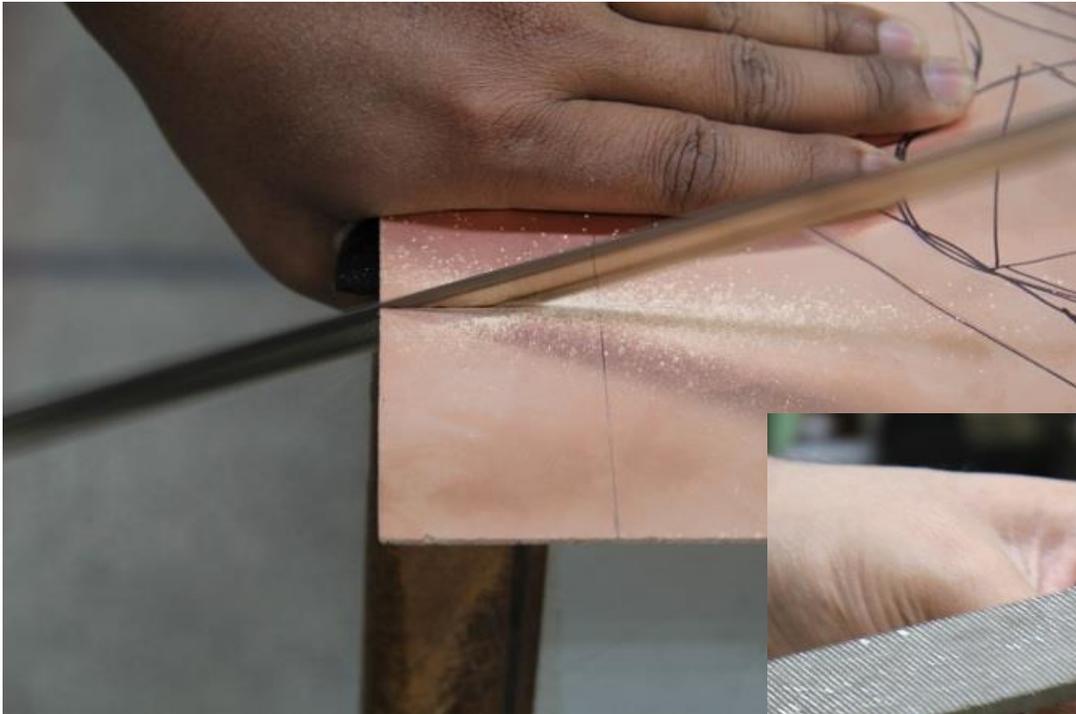
# Print Layout using Laser Printer



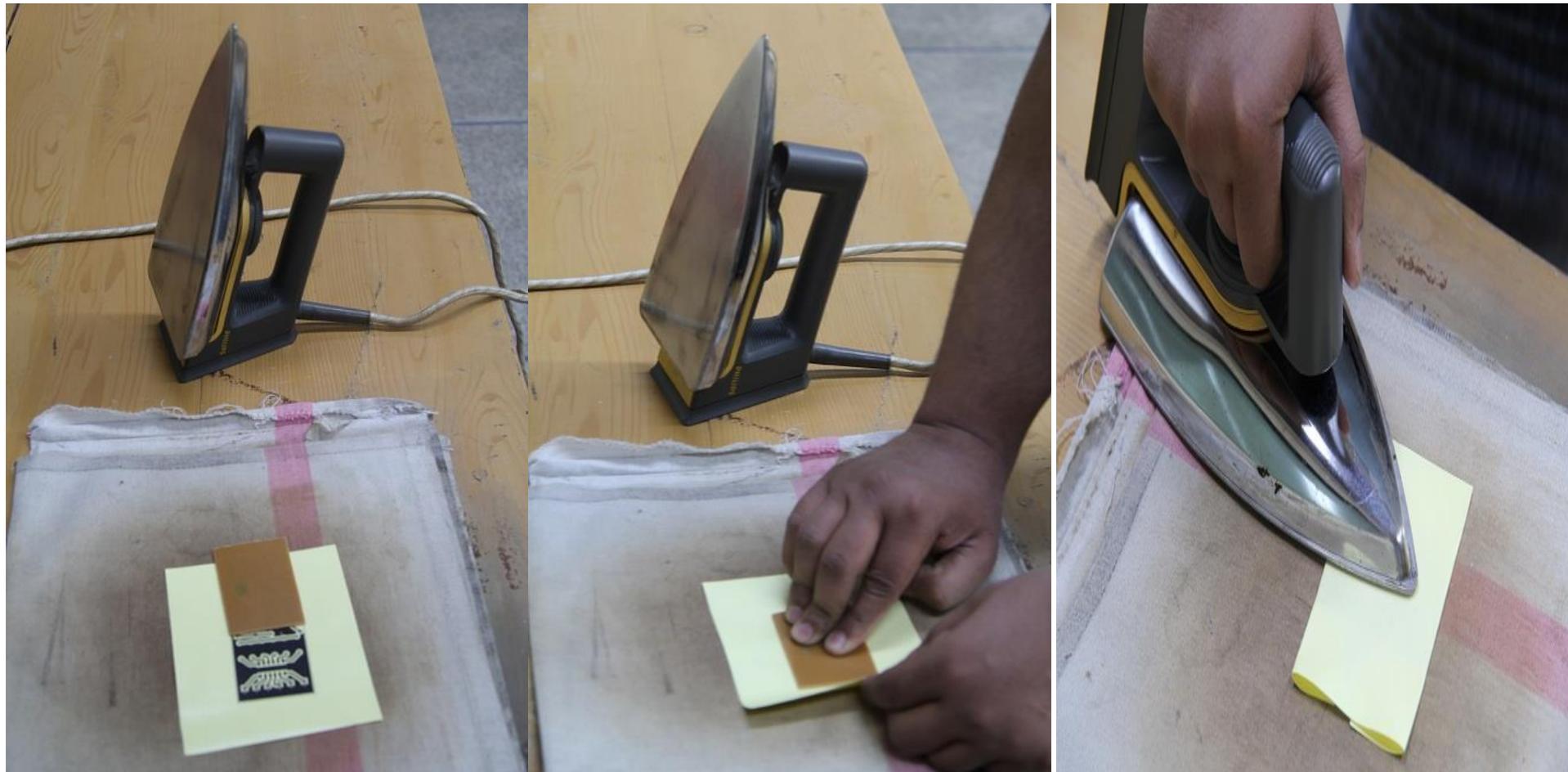
# Negative Image of Printed Layout



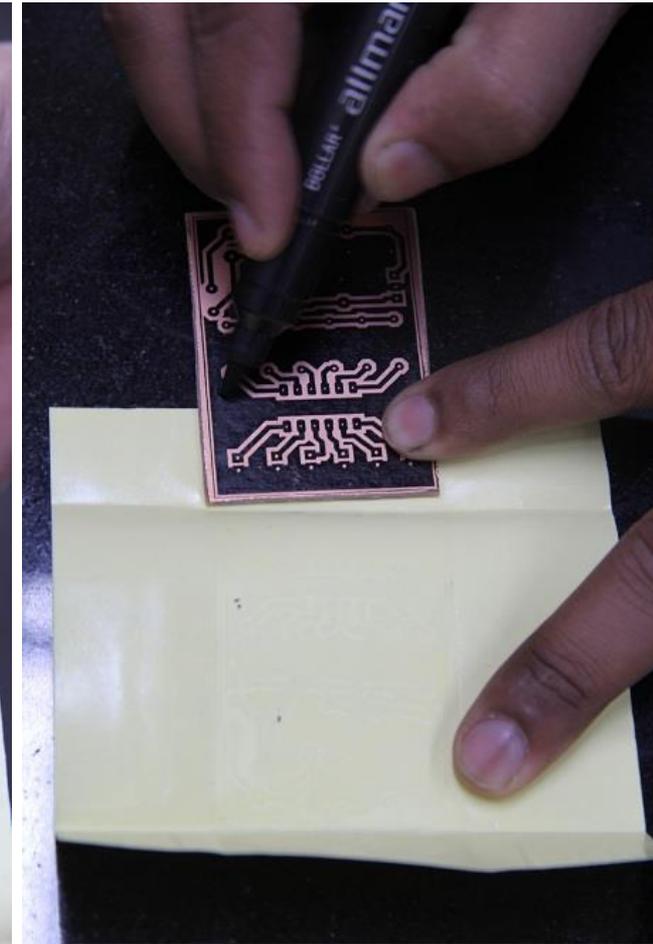
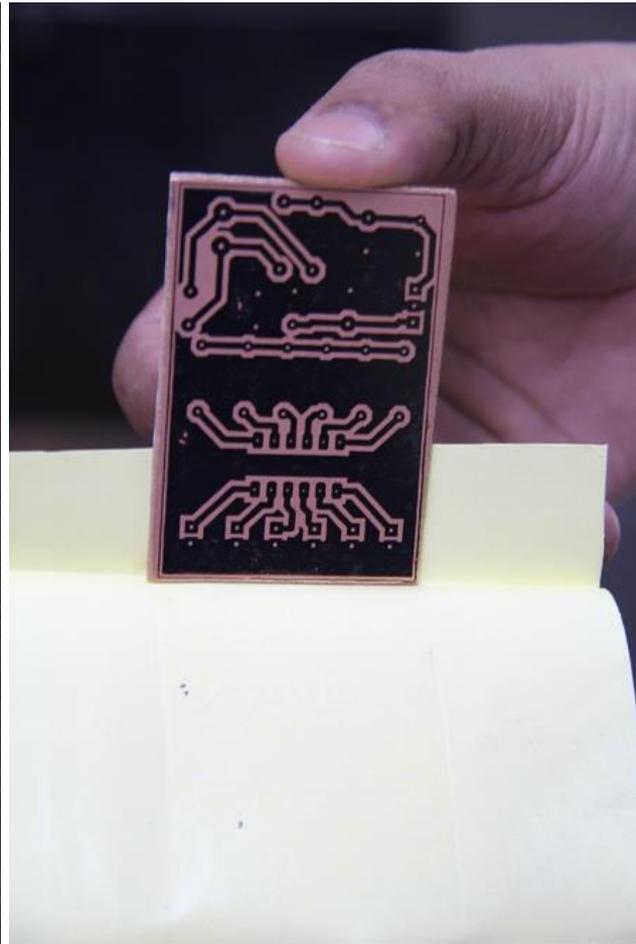
# Cut/File PCB Board



# Transfer Layout Image on PCB



# Ink Transferred on PCB



# Use Hot Water and FeCl<sub>3</sub>



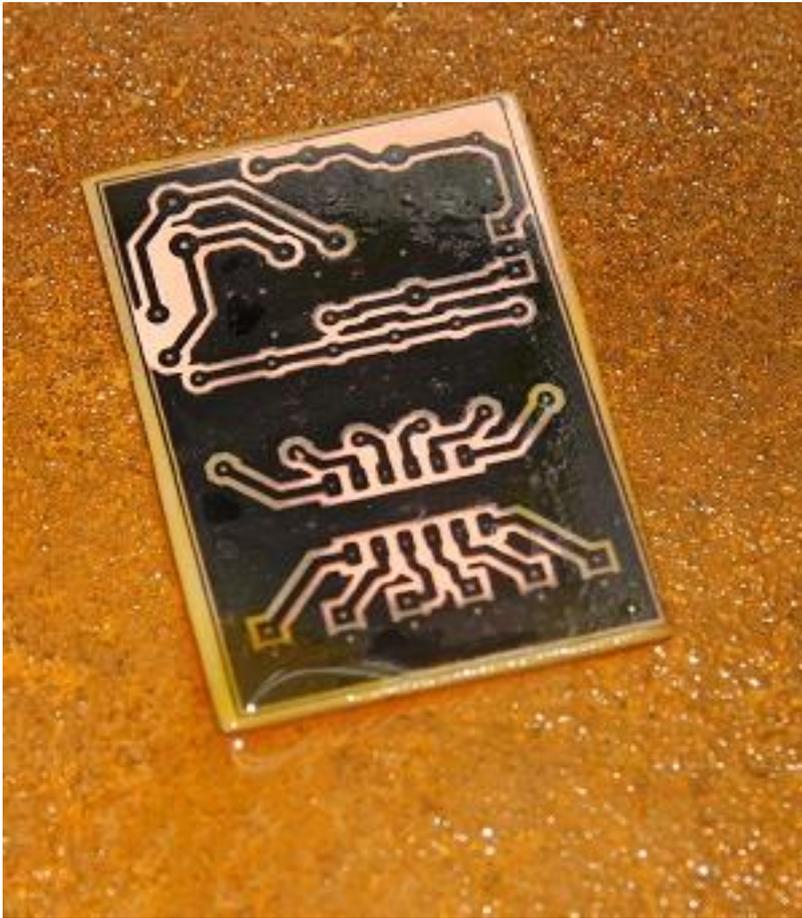
# FeCl<sub>3</sub> and PCB Inside Etching Tank



# Add boiling water into the tank and stir the solution



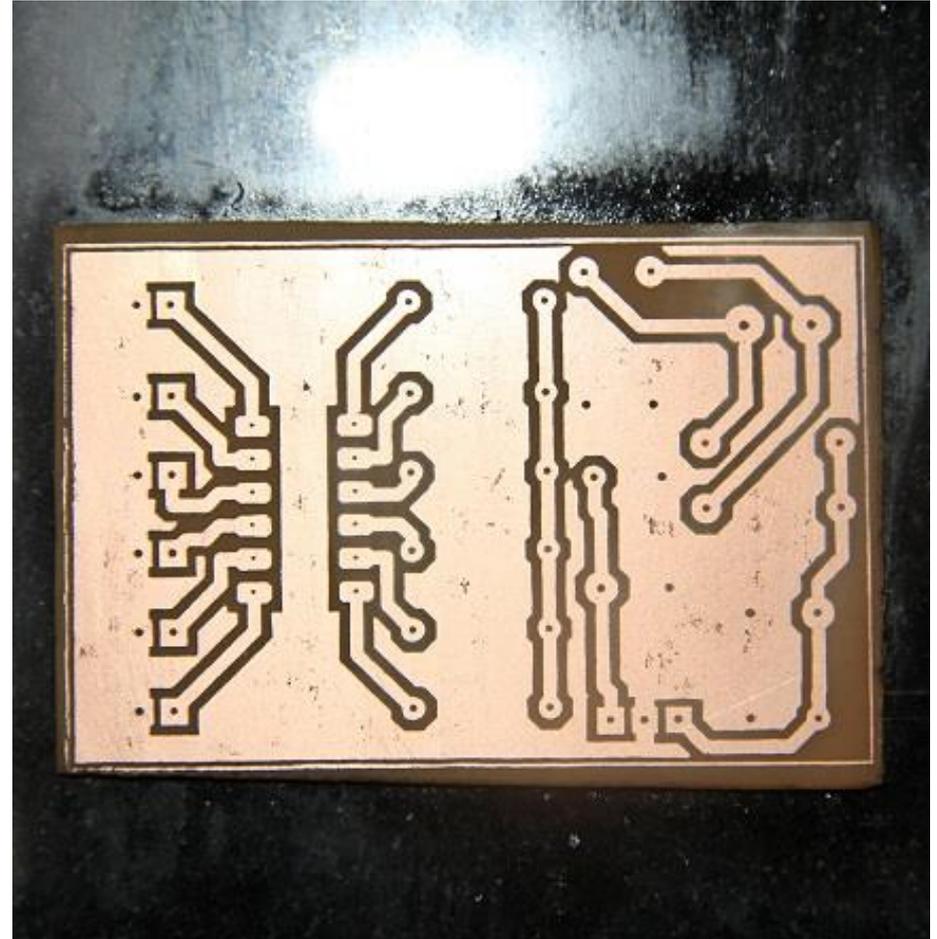
# Exposed copper is being dissolved into $\text{FeCl}_3$ solution



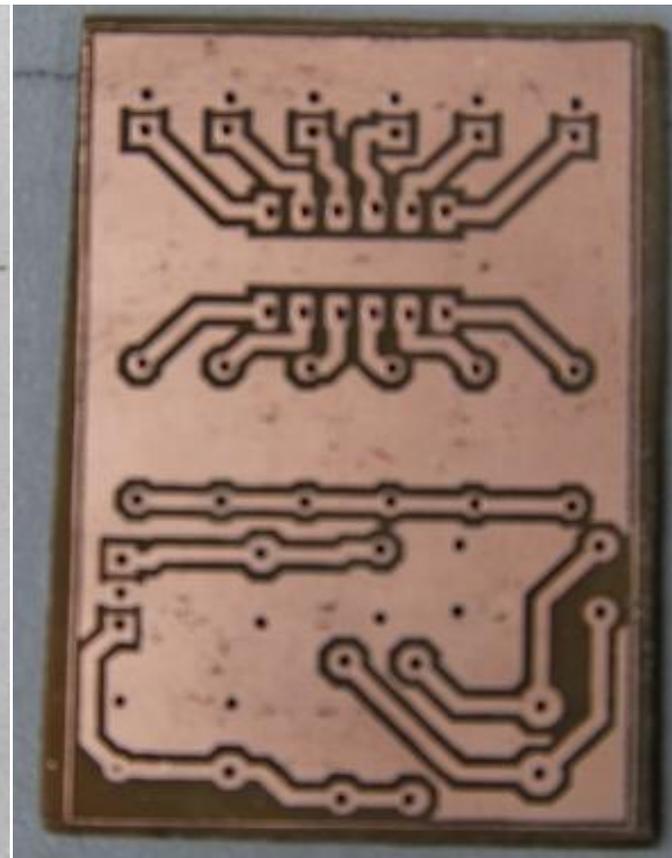
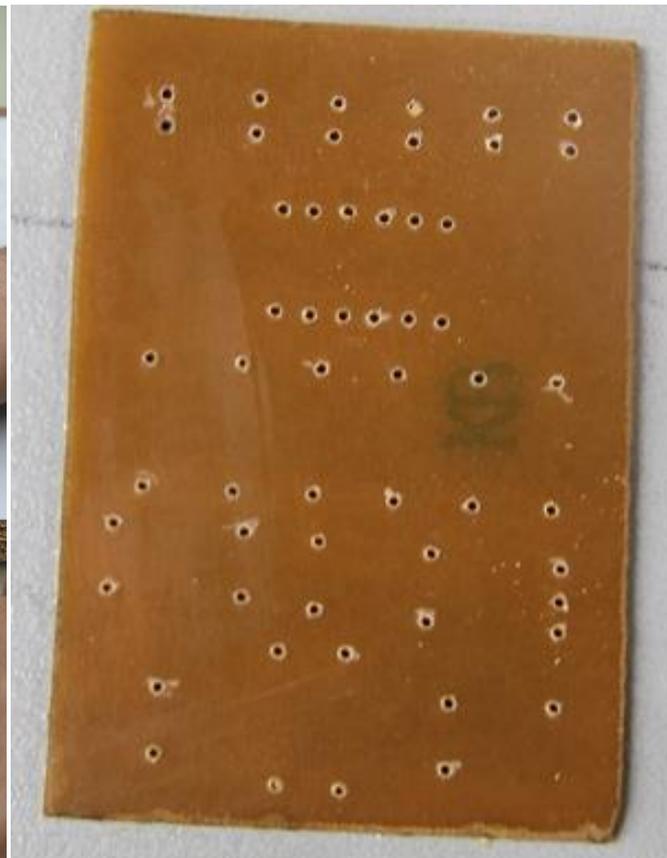
# Wash after Etching



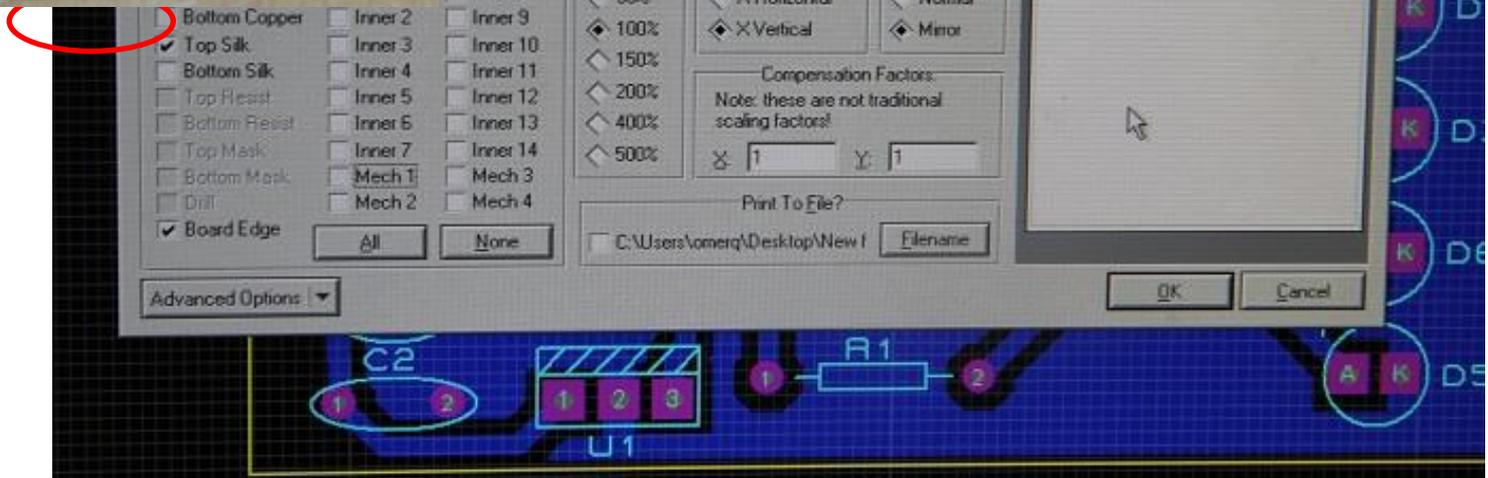
# Use Petrol to remove Printer Ink from Etched PCB



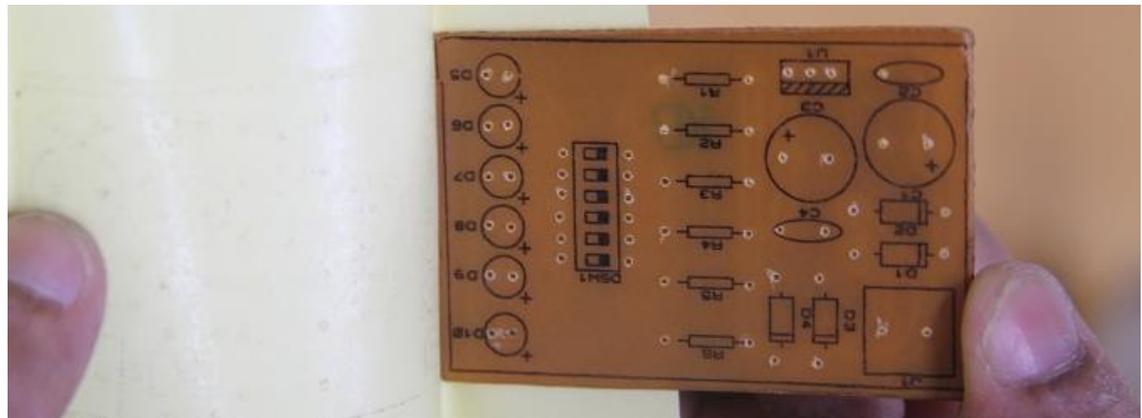
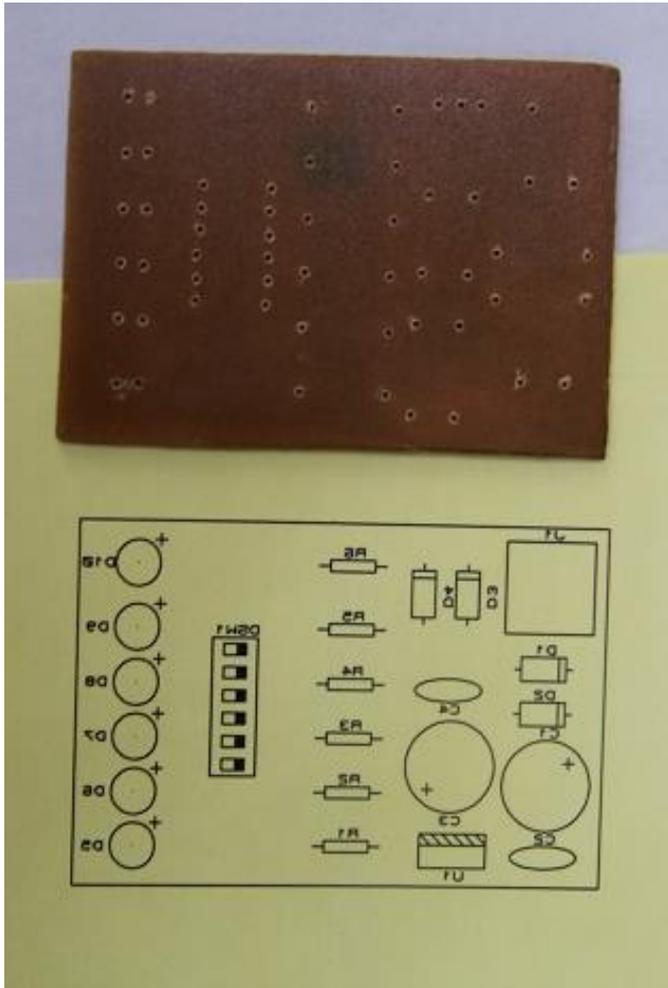
# Hand Drilling



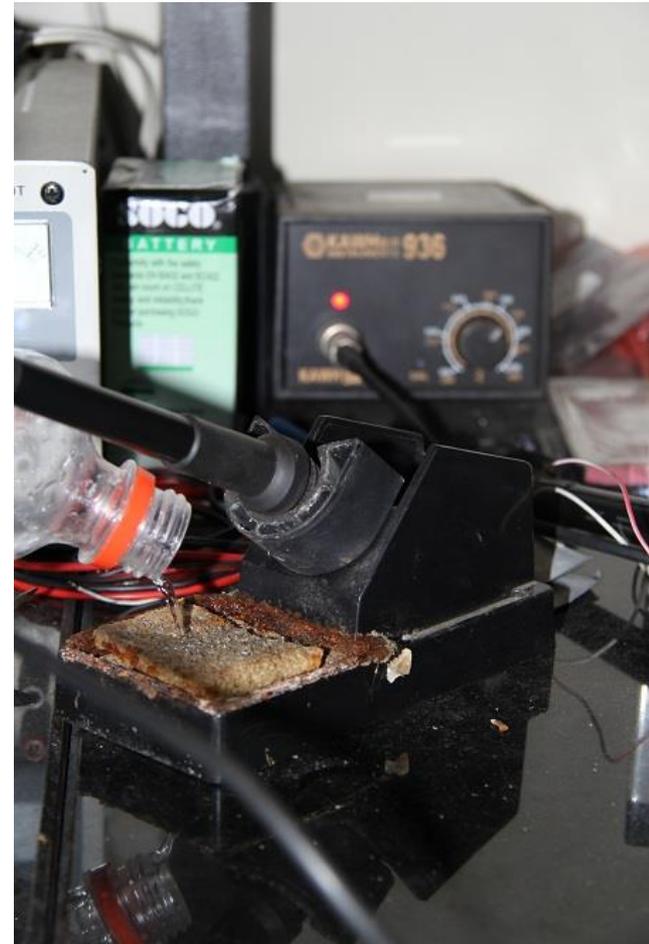
# Prepare Butter Paper for Silk Screen Printing



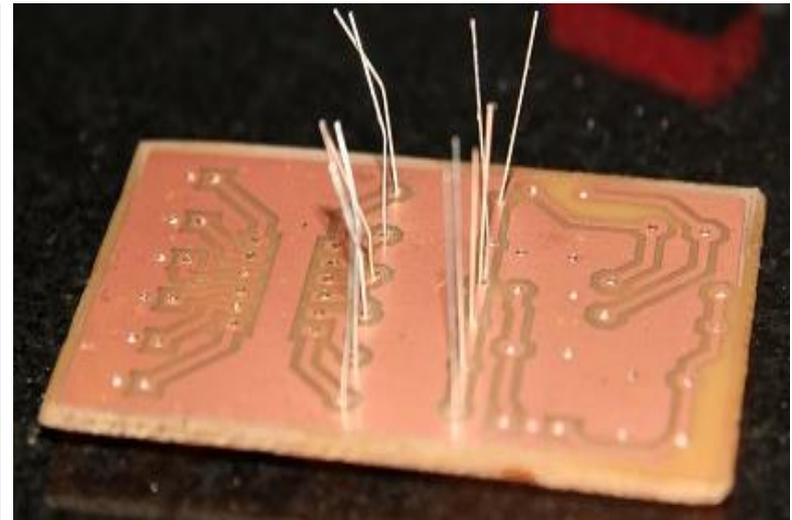
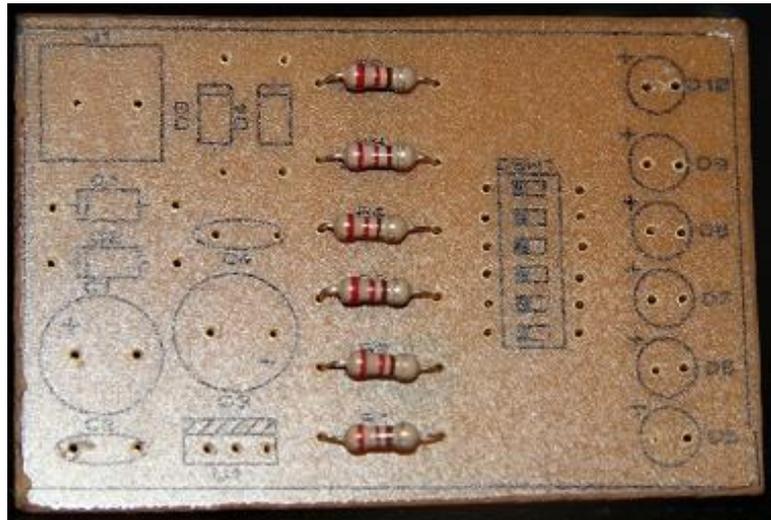
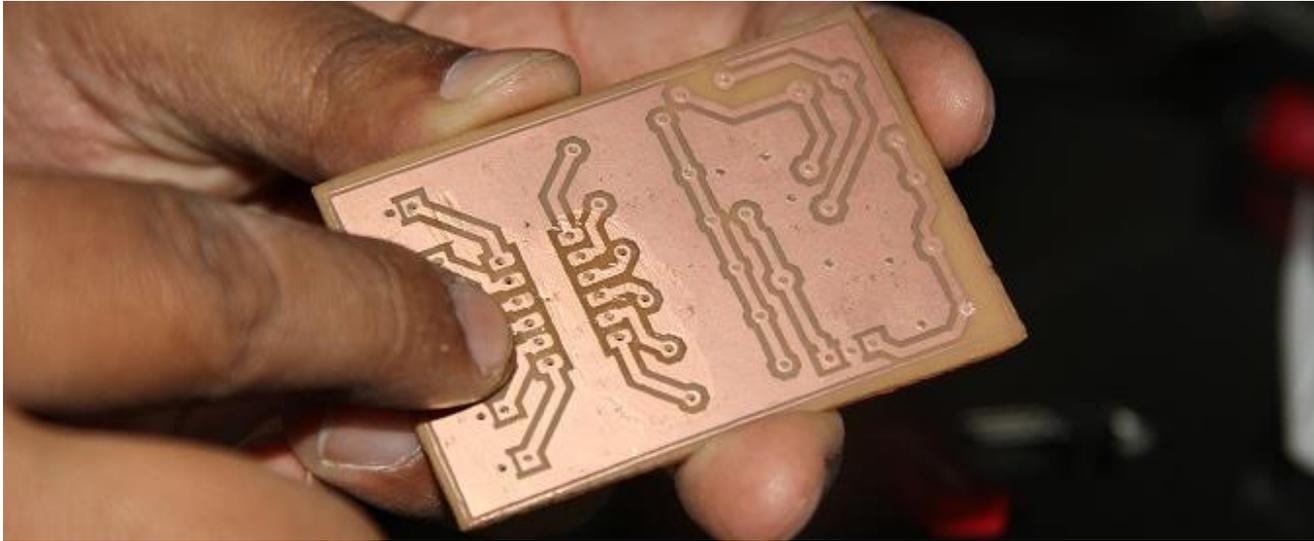
# Transfer Silk Screen on PCB



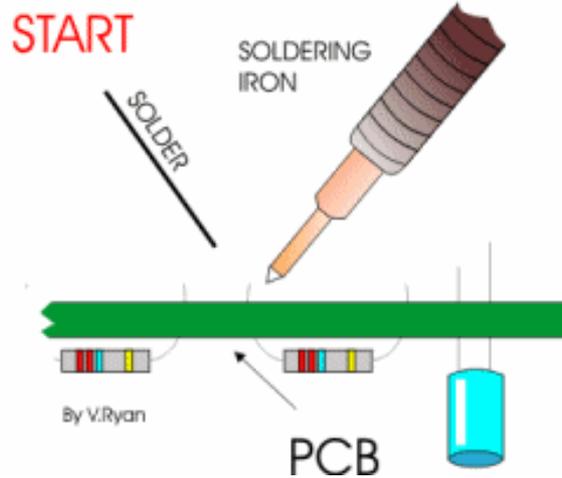
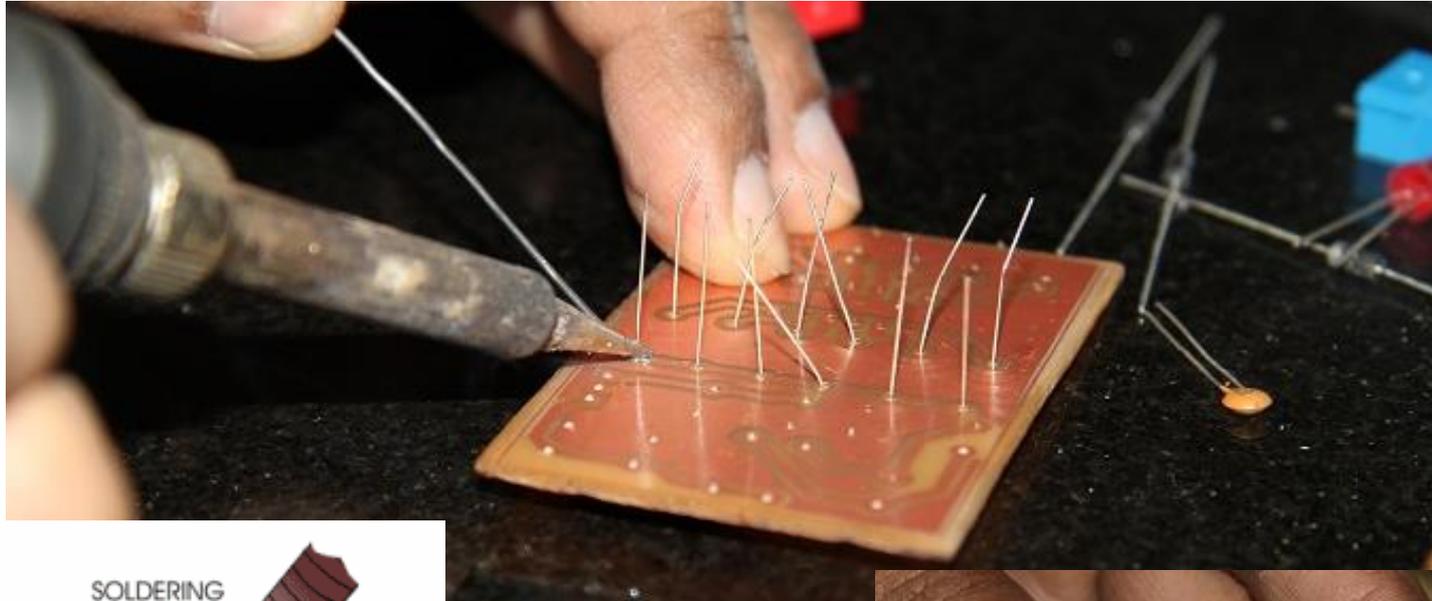
# Prepare Soldering Work Station



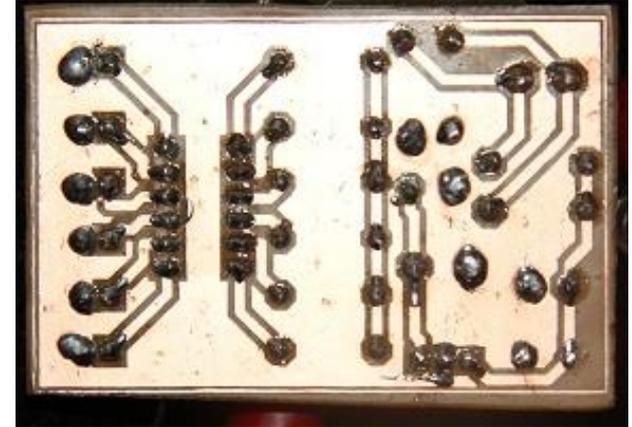
# Apply Soldering Paste and Embed Resistors



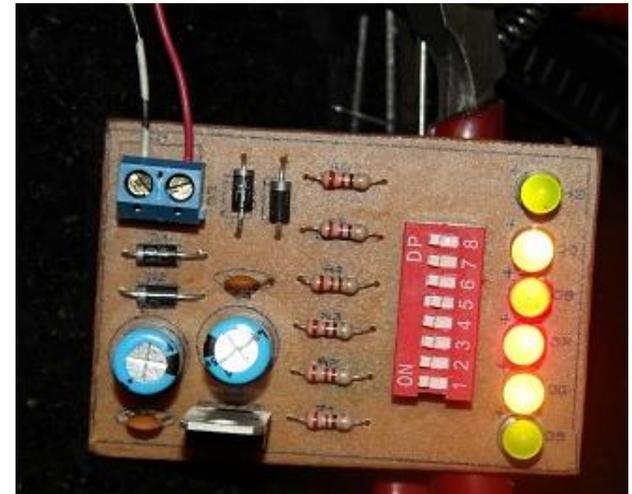
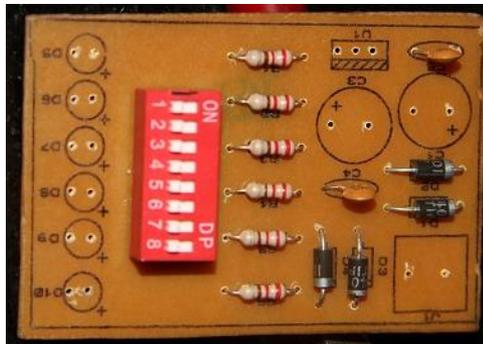
# Solder Component Legs



# Solder Components (Smaller to Bigger)

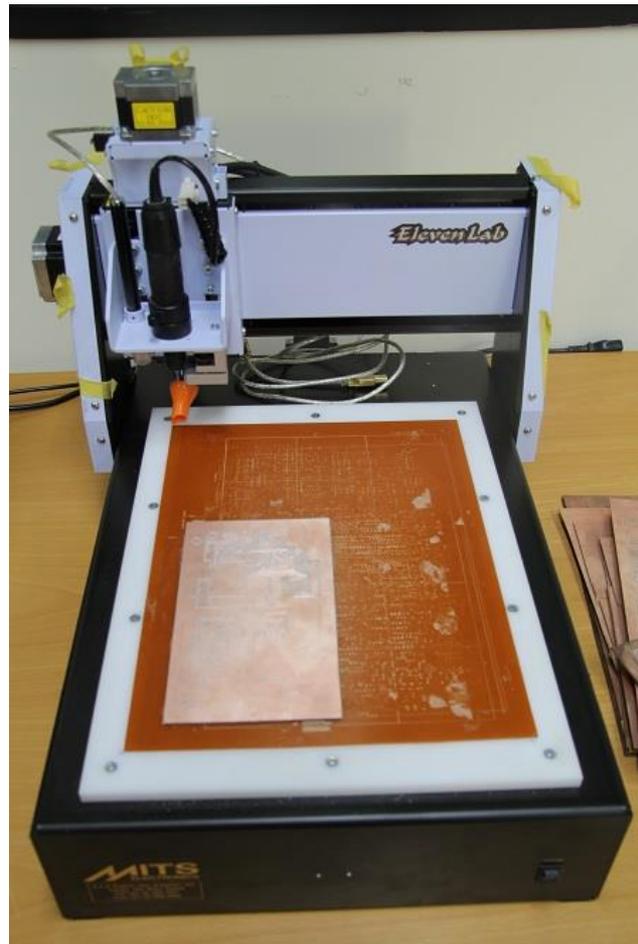


Testing (Power Up)



# **NON-CONVENTIONAL PCB PROTOTYPING**

# CNC Machine



# Create CAD/CAM Files

The image shows a screenshot of a PCB design software interface. The main window displays a PCB layout with various components and traces. A menu is open, showing options for exporting files. The 'Gerber/Excellon Output...' option is highlighted with a red circle. The 'CAD/CAM (Gerber and Excellon) Output' dialog box is also open, showing settings for output generation. The 'Layers/Artworks' section is visible, with 'Bottom Copper', 'Drill', and 'Edge (will appear on all layers)' checked. The 'Rotation' section shows 'X Horizontal' selected. The 'Gerber Format' is set to 'RS274X'. The 'Resolution' is set to '1000 dpi'.

**Output** View Edit Library Tools System Help

- Print...
- Printer Setup...
- Printer Information
- Set Output Area
- Set Output Origin
- Export Graphics
- Pre Production Check...
- Manufacturing Notes...
- Gerber/Excellon Output...**
- Gerber View...
- Pick and Place file...
- Testpoint Information file...
- ODB++ Output...
- IDF Output...
- 3D Visualization

**CAD/CAM (Gerber and Excellon) Output**

CAD/CAM Output | CAD/CAM Notes

Output Generation

Filestem: PCB Module - Task1-2  
Folder: \Engineering Laboratory

Output to individual TXT files?  
 Output to a single ZIP file?

Automatically open output folder  
 Automatically open ZIP file?

Layers/Artworks:

<input type="checkbox"/> Top Copper	<input type="checkbox"/> Inner 1	<input type="checkbox"/> Inner 8
<input checked="" type="checkbox"/> Bottom Copper	<input type="checkbox"/> Inner 2	<input type="checkbox"/> Inner 9
<input type="checkbox"/> Top Silk	<input type="checkbox"/> Inner 3	<input type="checkbox"/> Inner 10
<input type="checkbox"/> Bottom Silk	<input type="checkbox"/> Inner 4	<input type="checkbox"/> Inner 11
<input type="checkbox"/> Top resist	<input type="checkbox"/> Inner 5	<input type="checkbox"/> Inner 12
<input type="checkbox"/> Bottom Resist	<input type="checkbox"/> Inner 6	<input type="checkbox"/> Inner 13
<input type="checkbox"/> Top Mask	<input type="checkbox"/> Inner 7	<input type="checkbox"/> Inner 14
<input type="checkbox"/> Bottom Mask	<input checked="" type="checkbox"/> Mech 1	<input type="checkbox"/> Mech 3
<input checked="" type="checkbox"/> Drill	<input type="checkbox"/> Mech 2	<input type="checkbox"/> Mech 4
<input checked="" type="checkbox"/> Edge (will appear on all layers)		

Apply Global Guard Gap 5th

Rotation:  
 X Horizontal  
 X Vertical

Reflection:  
 Normal  
 Mirror

INF File Units:  
 Imperial (thou)  
 Metric (mm)  
 Auto

Gerber Format:  
 RS274D  
 RS274X

Slotting/Routing Layer:  
Mech 1

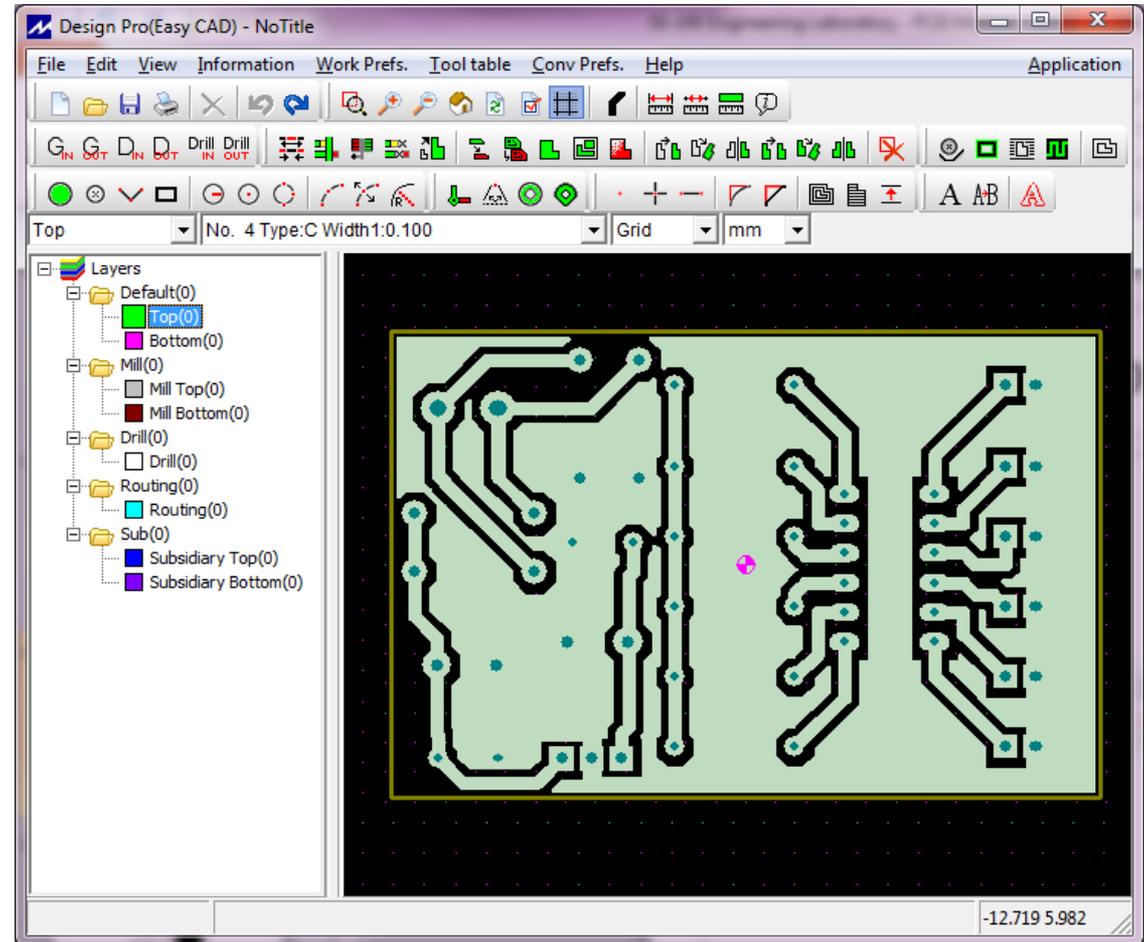
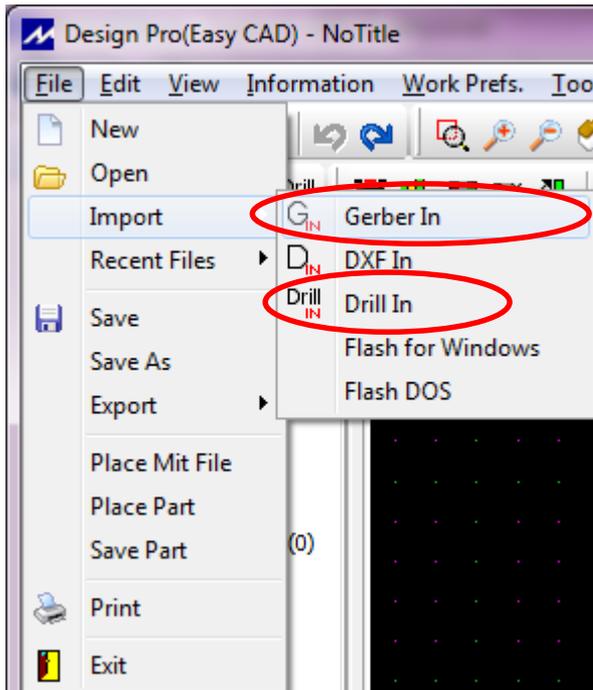
Bitmap/Font Rasterizer:  
Resolution: 1000 dpi

Run Gerber Viewer When Done?

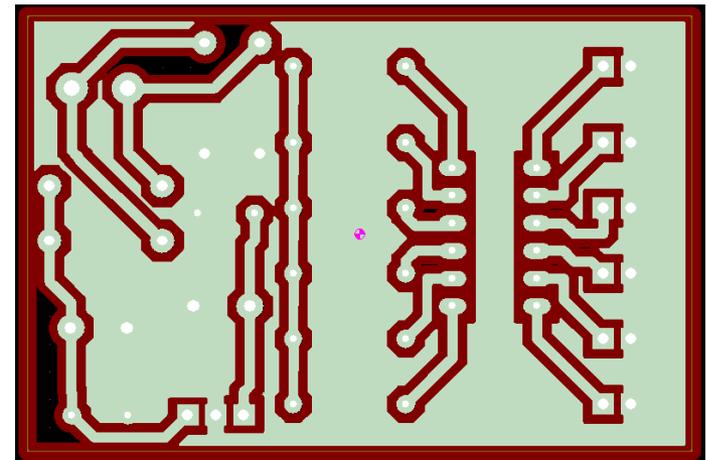
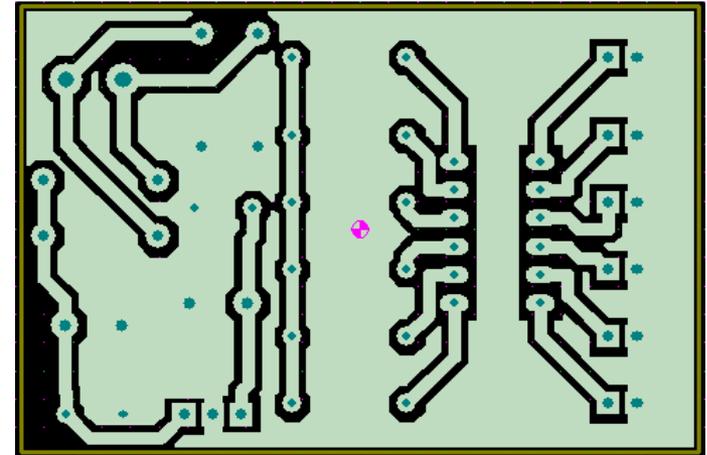
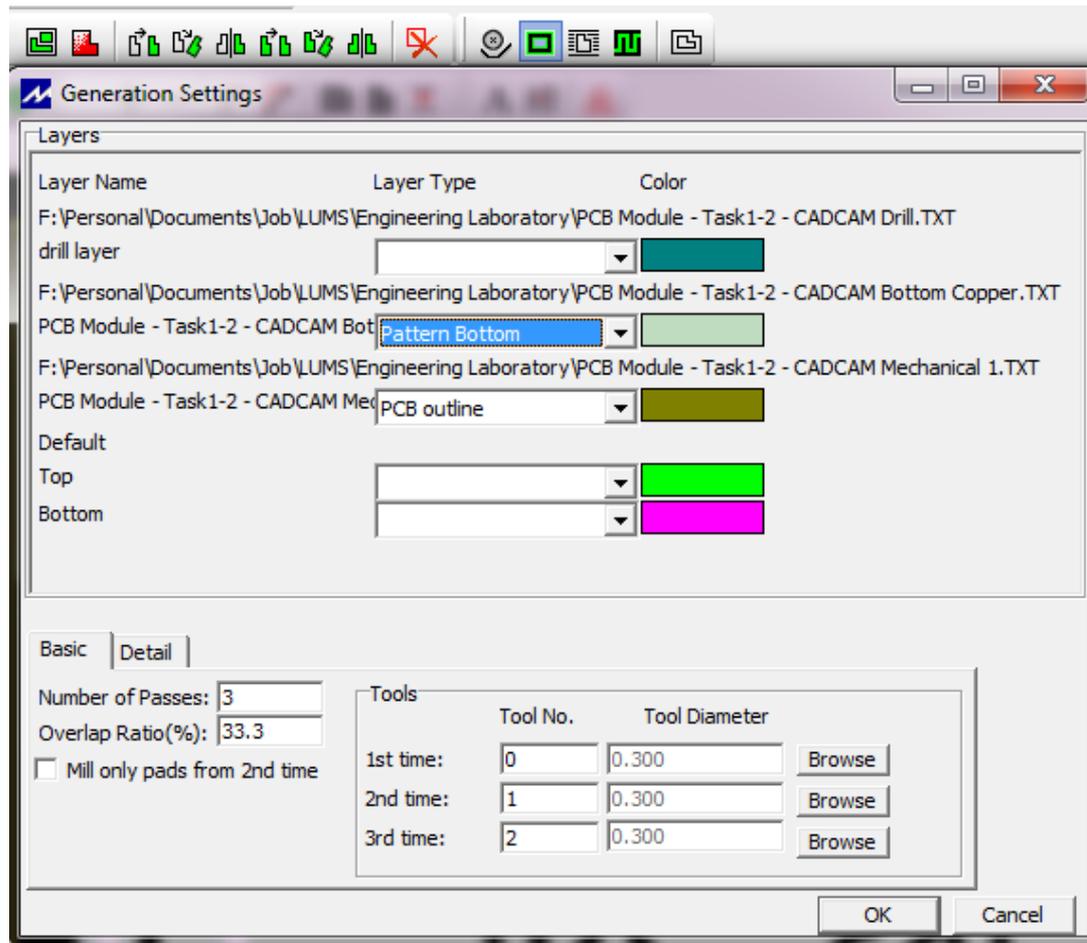
All None

OK Cancel

# Import PCB Outline/Tracks/Drill Layer into CNC Machine Software



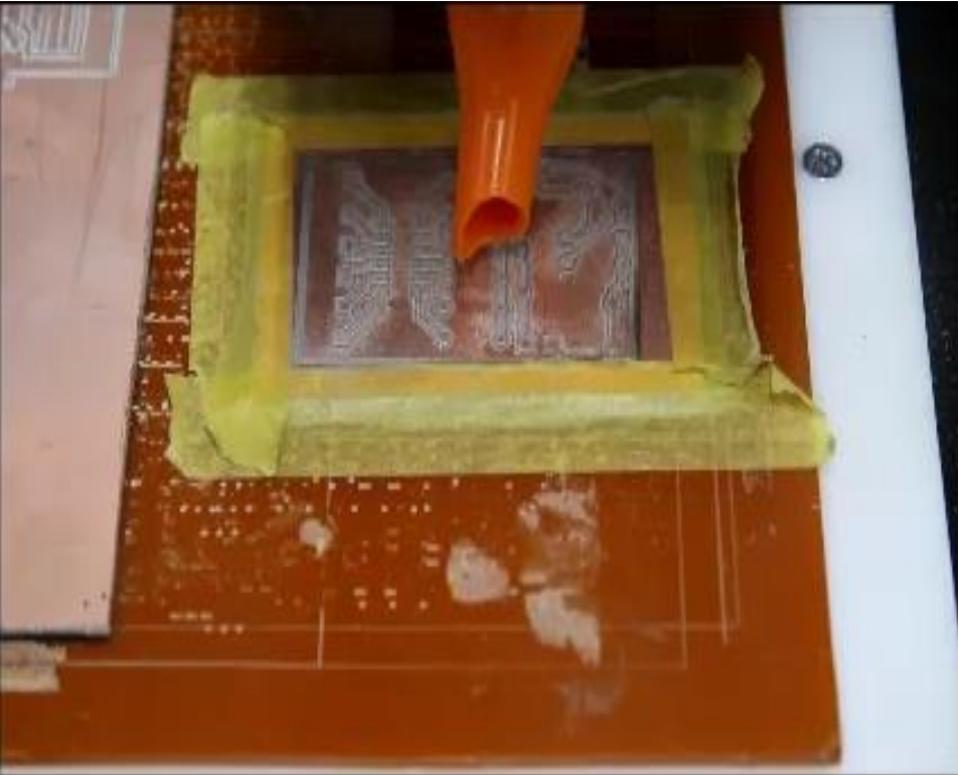
# Create Drilling Marks and Milling Outlines



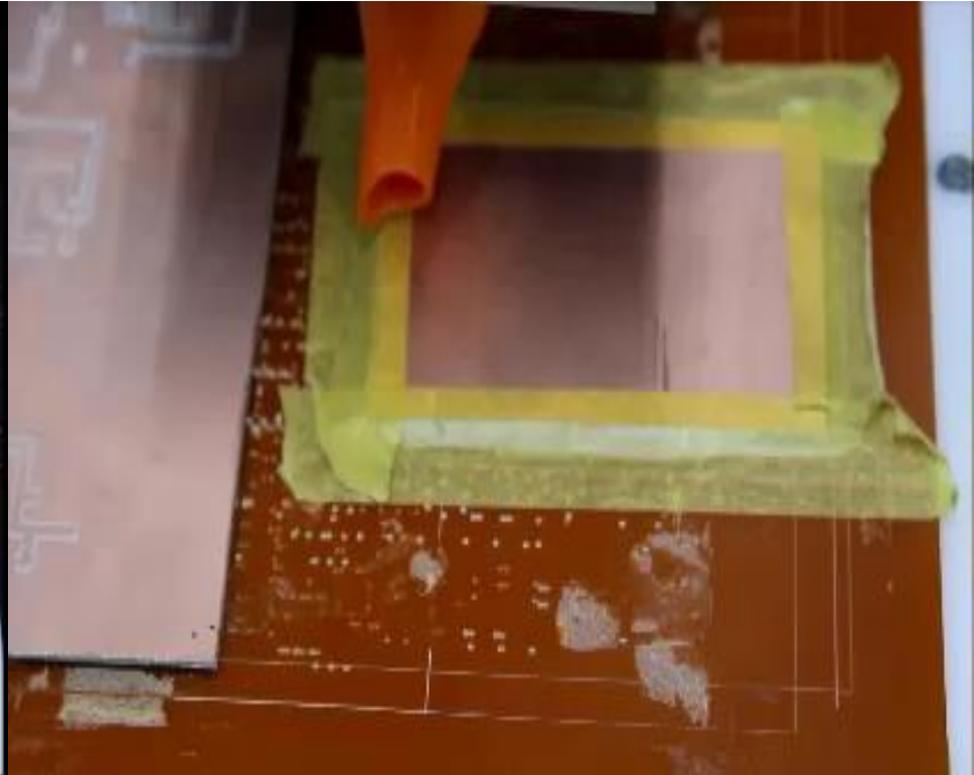
# Final Output



# Video Demonstration



**PCB Drilling**



**PCB Milling**

# Lab Visit

- Conventional PCB Prototyping



- Non-Conventional PCB Prototyping

