

EE-100 Engineering Laboratory

Module1: PCB

Dr. –Ing. Ahmad Kamal Nasir

[Office Hours]

Tuesday (1200-1300)

Thursday (1200-1300)

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

Module 1

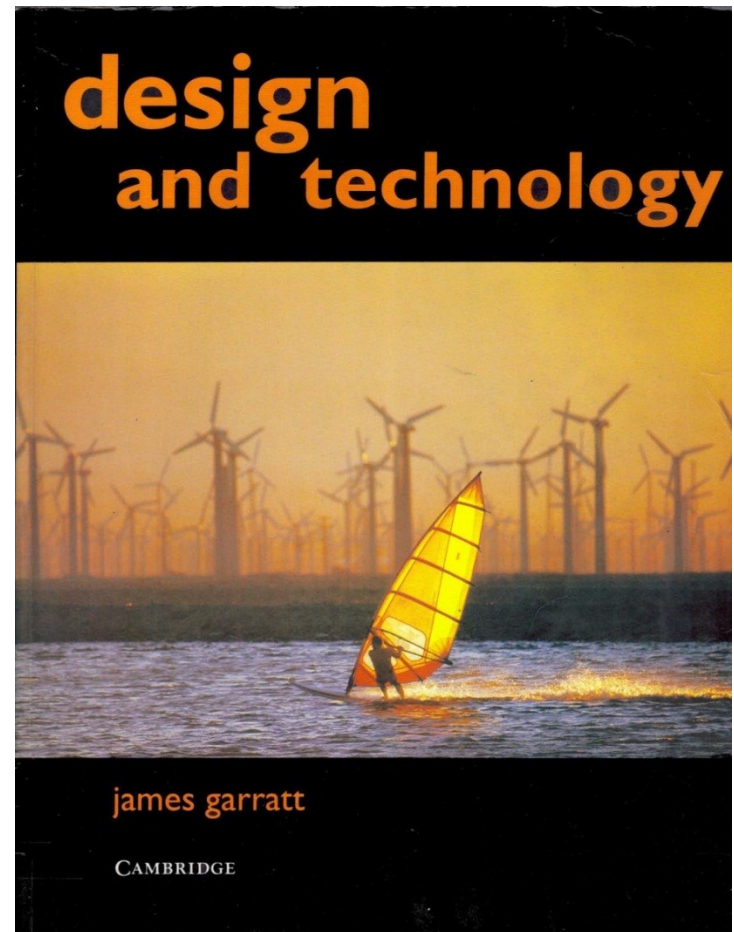
WEEK1

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

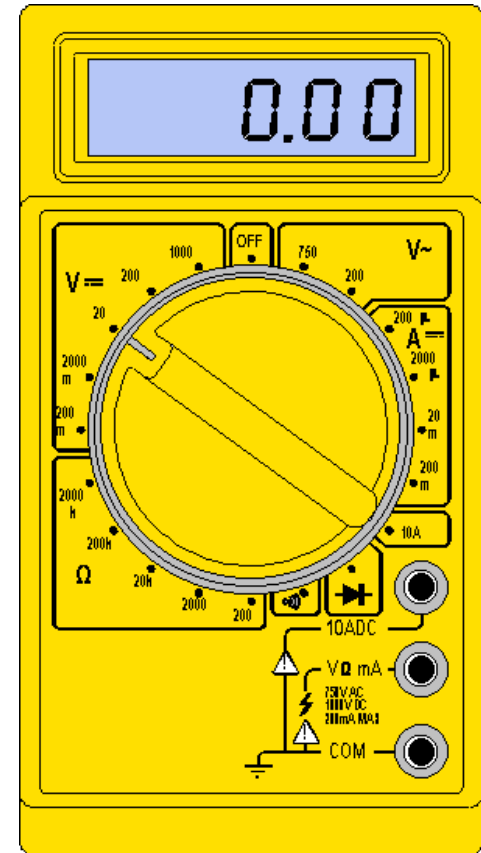
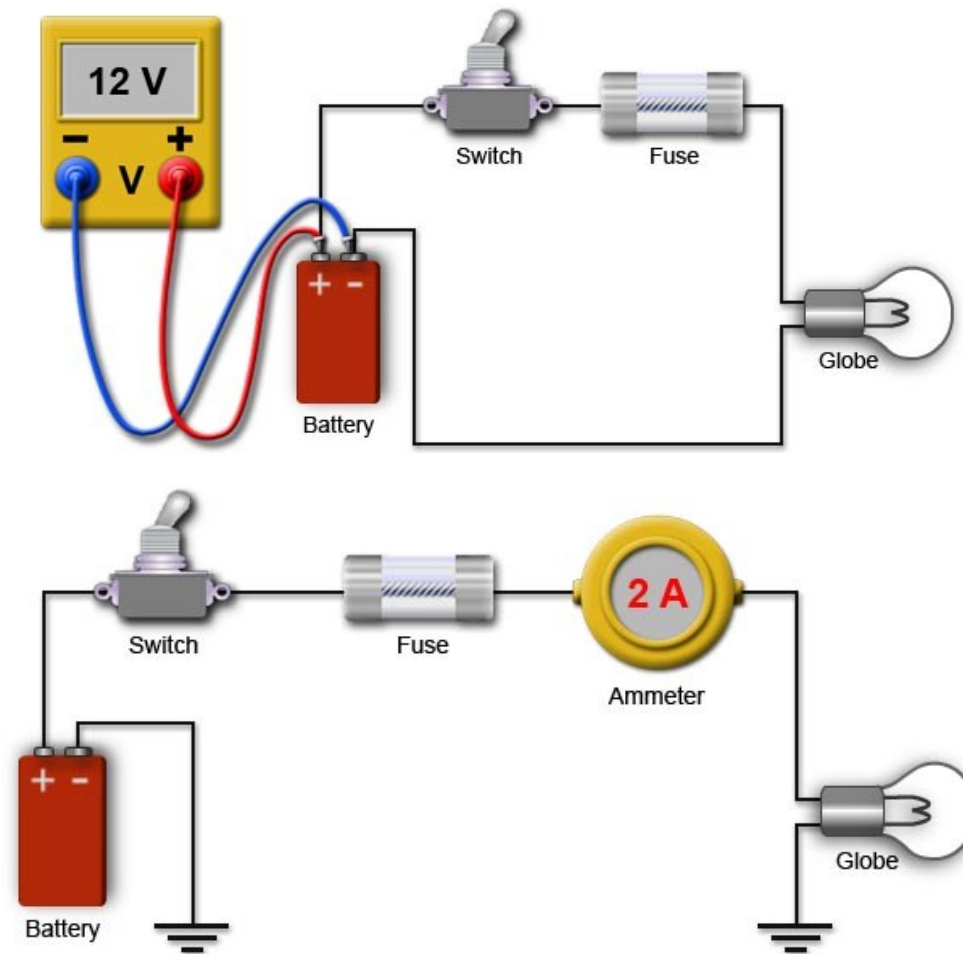
Reference

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

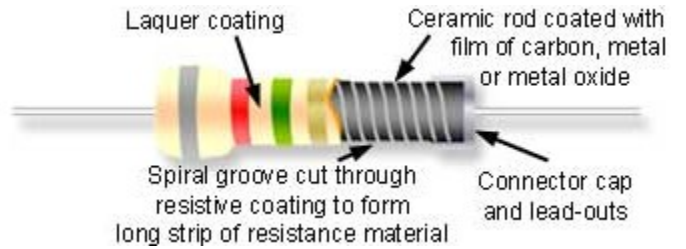
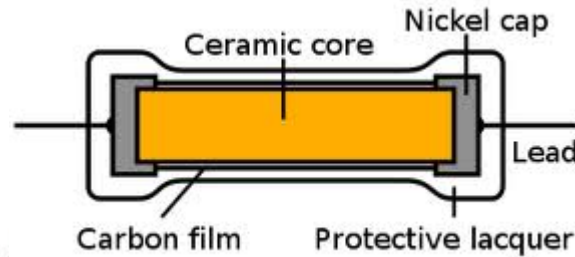


ELECTRONICS BASICS (REVIEW)

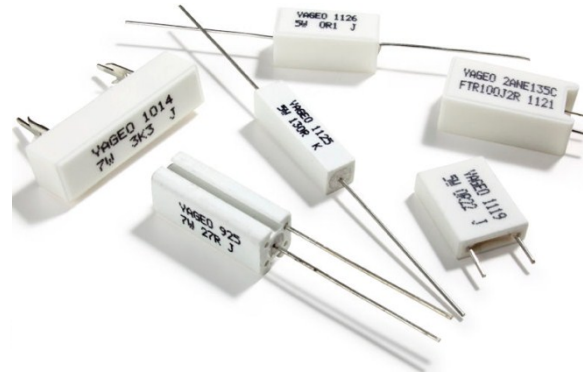
Voltage/Current Measurements



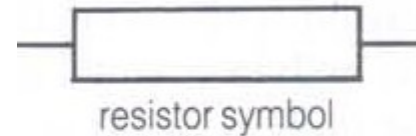
Resistor



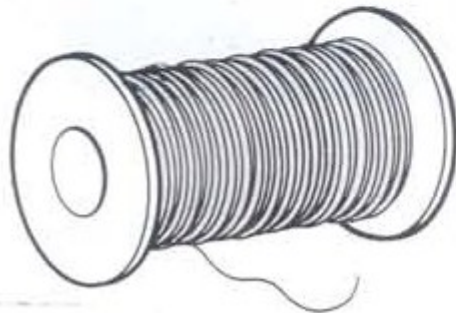
carbon resistor
(see colour code p.115)



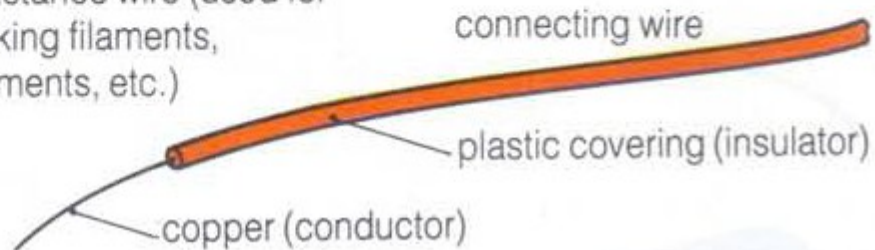
wire-wound resistor



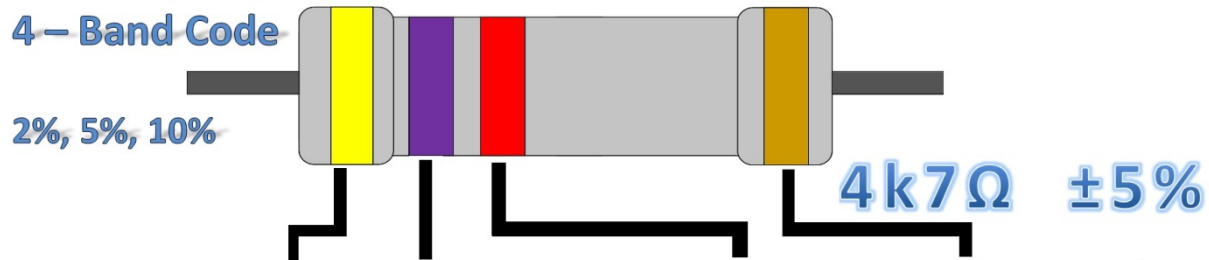
resistor symbol



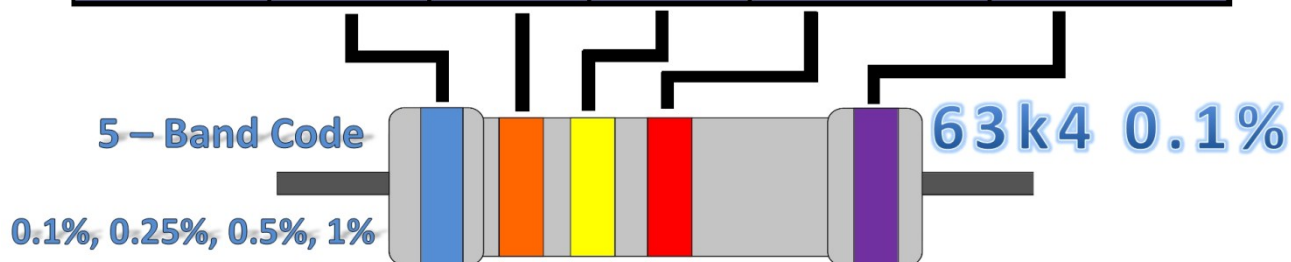
resistance wire (used for making filaments, elements, etc.)



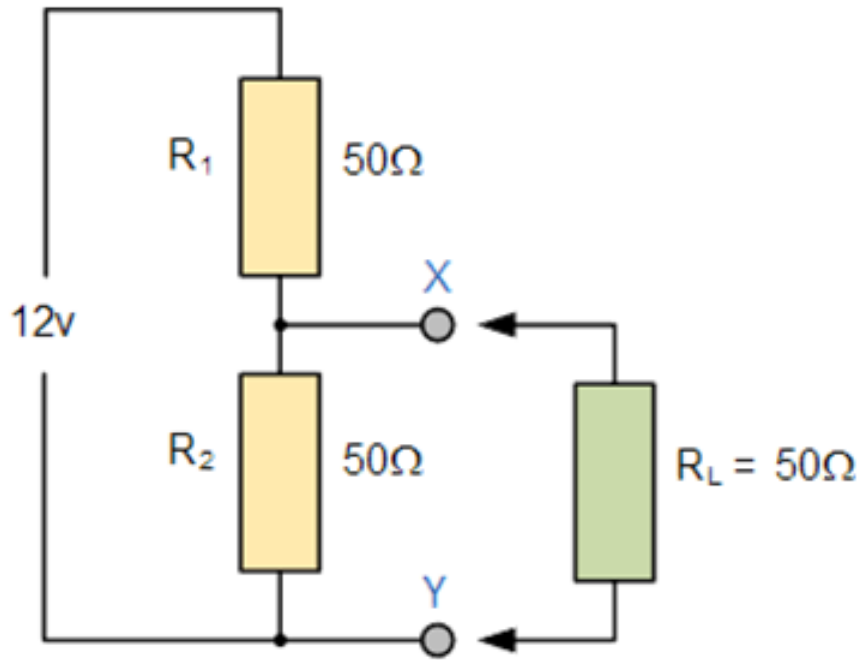
Resistor Color Code



Color	1 st Band	2 nd Band	3 rd 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%



Voltage Divider

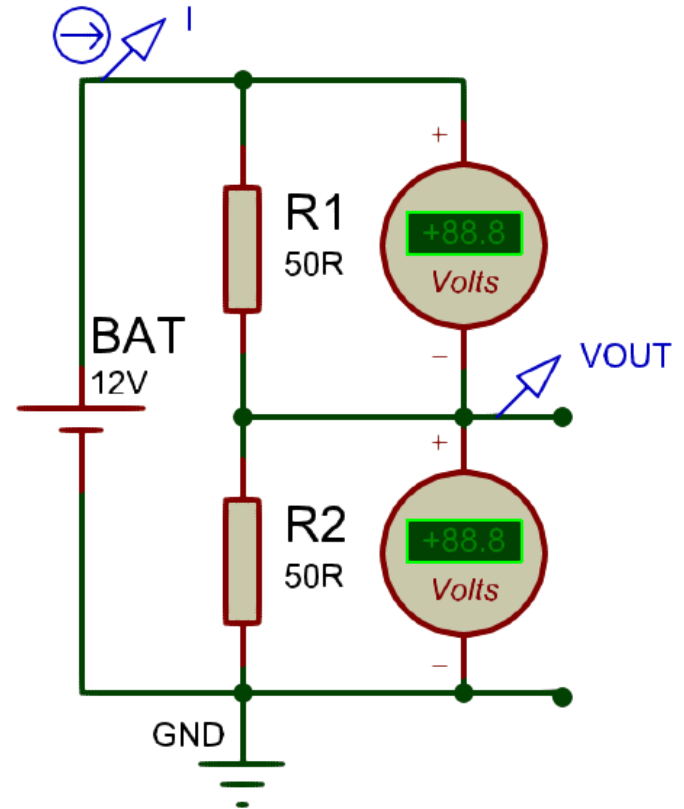


a) Without R_L connected

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

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

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



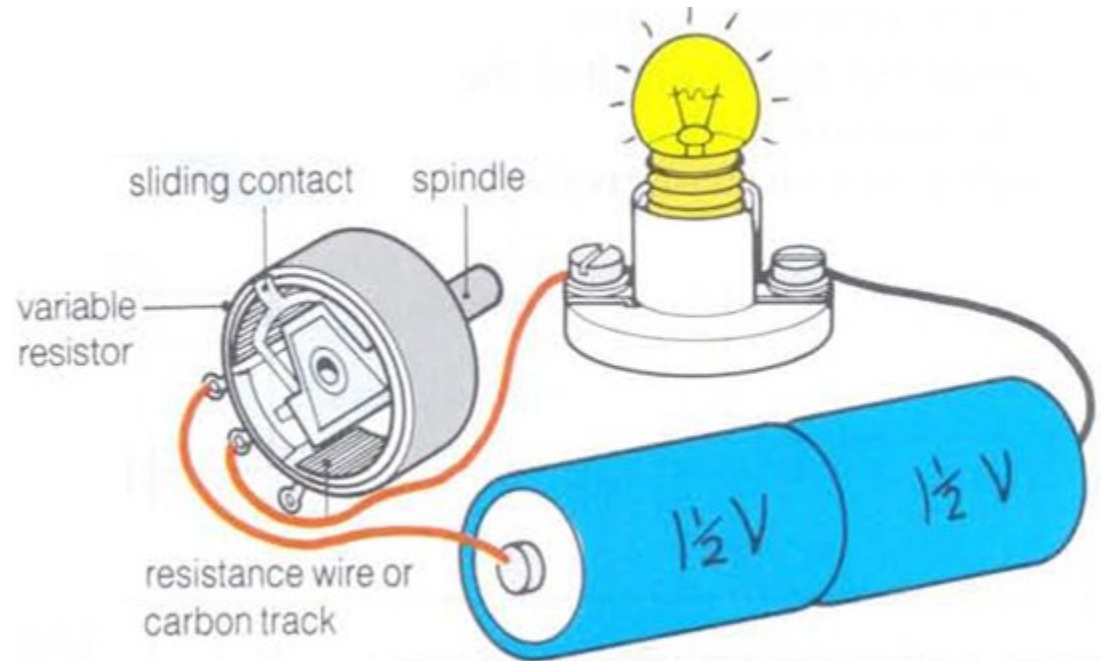
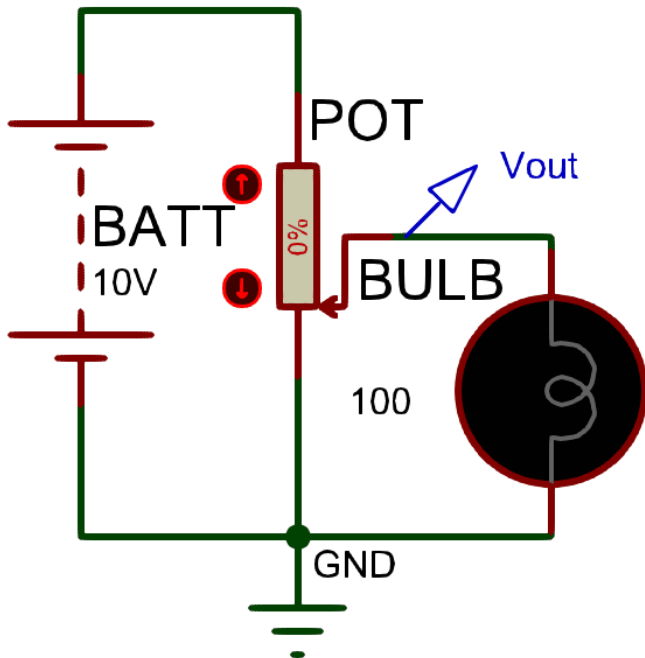
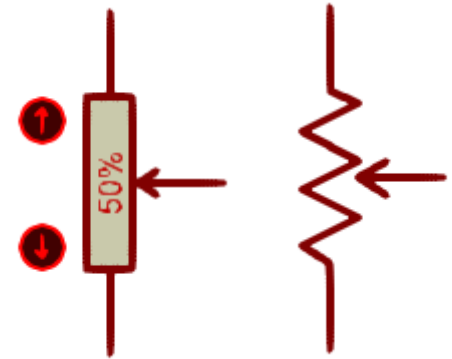
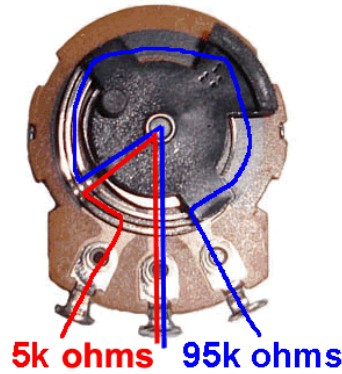
b) With R_L connected

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

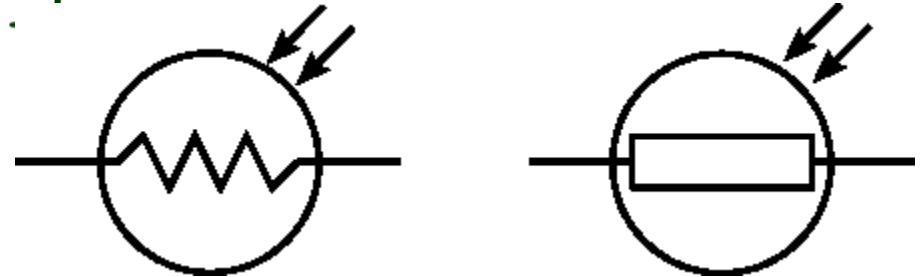
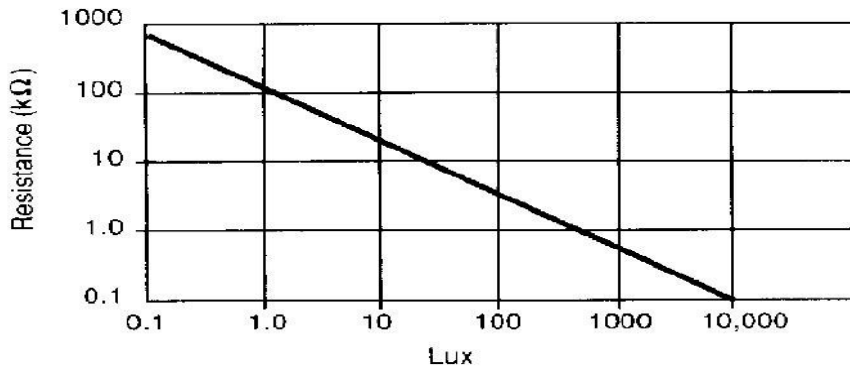
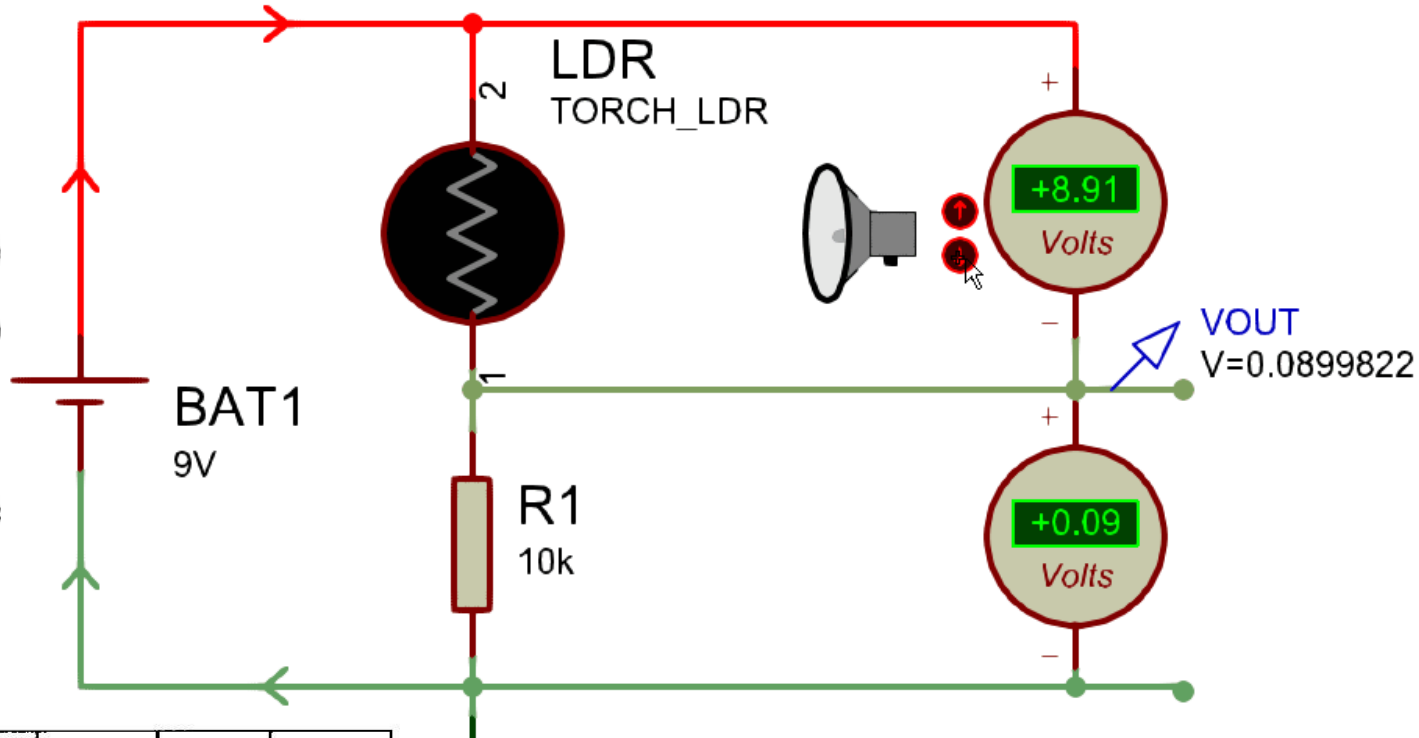
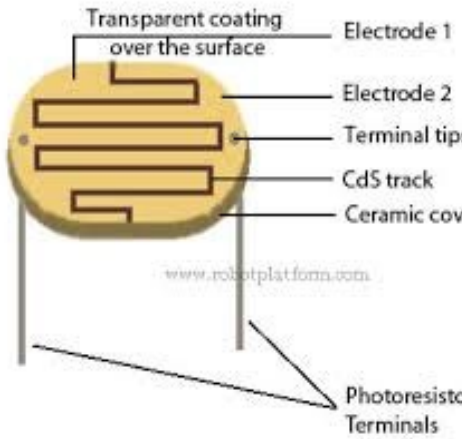
$$V_{out} = V_{in} \times \frac{R_2}{R_1 + R_2}$$

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

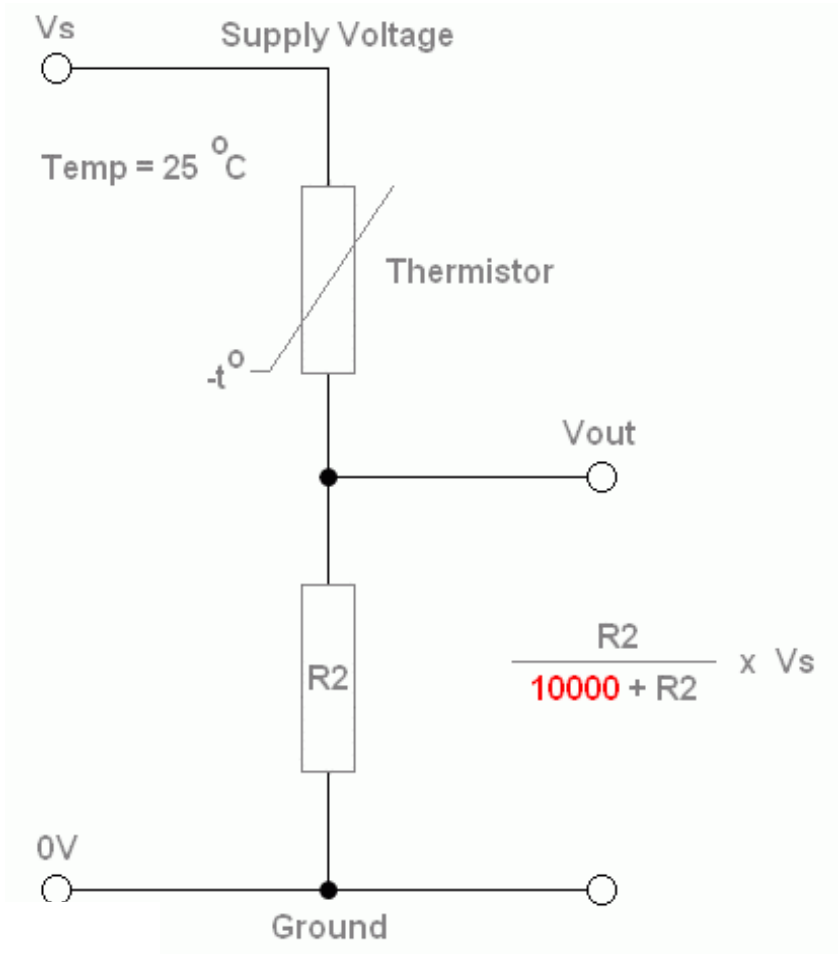
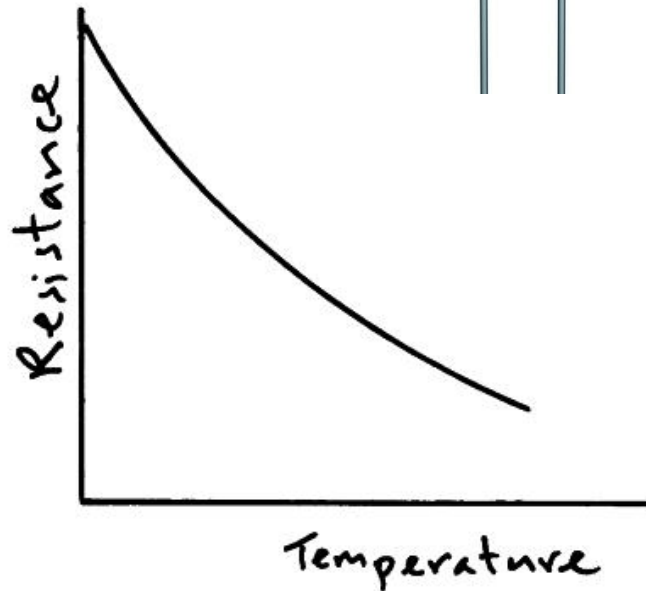
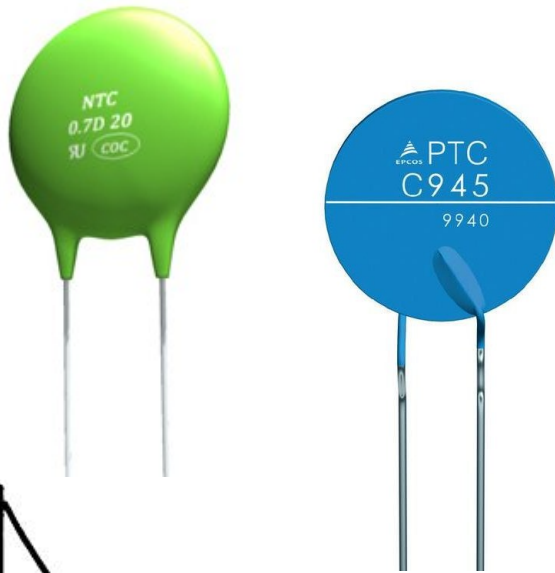
Variable Resistor



Light Dependent Resistor (LDR)



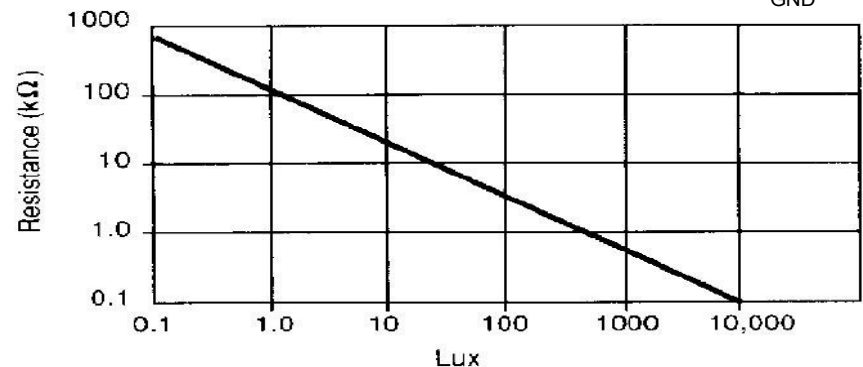
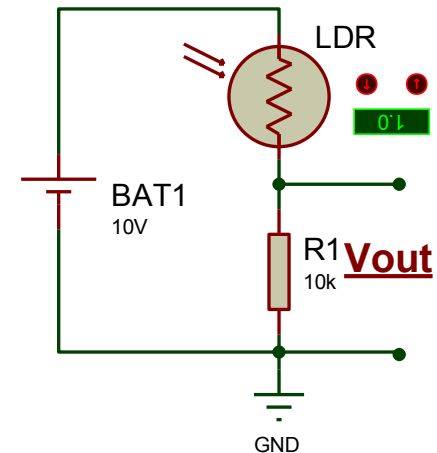
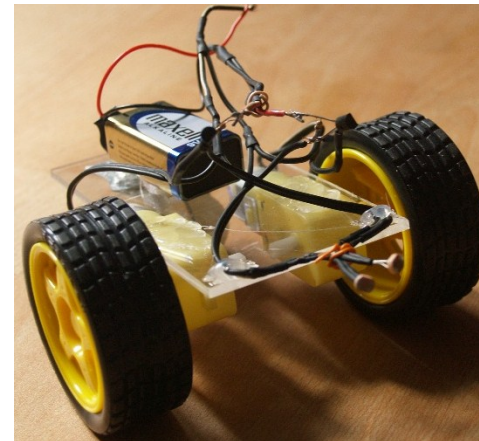
Thermistor



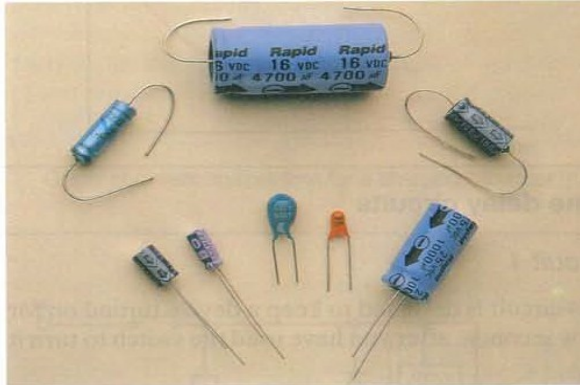
Lab Task 1(a)

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.

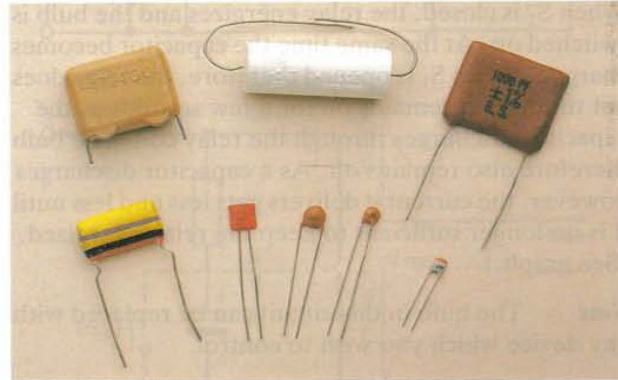
- Sketch the graph of V_{out} against intensity?
- Sketch the graph of V_{out} against intensity if the position of resistor R and LDR swapped?
- Redesign the value of the resistor such that $V_{out} = 1V$ at a light intensity of 1 Lux?



Capacitor



Polarized capacitors



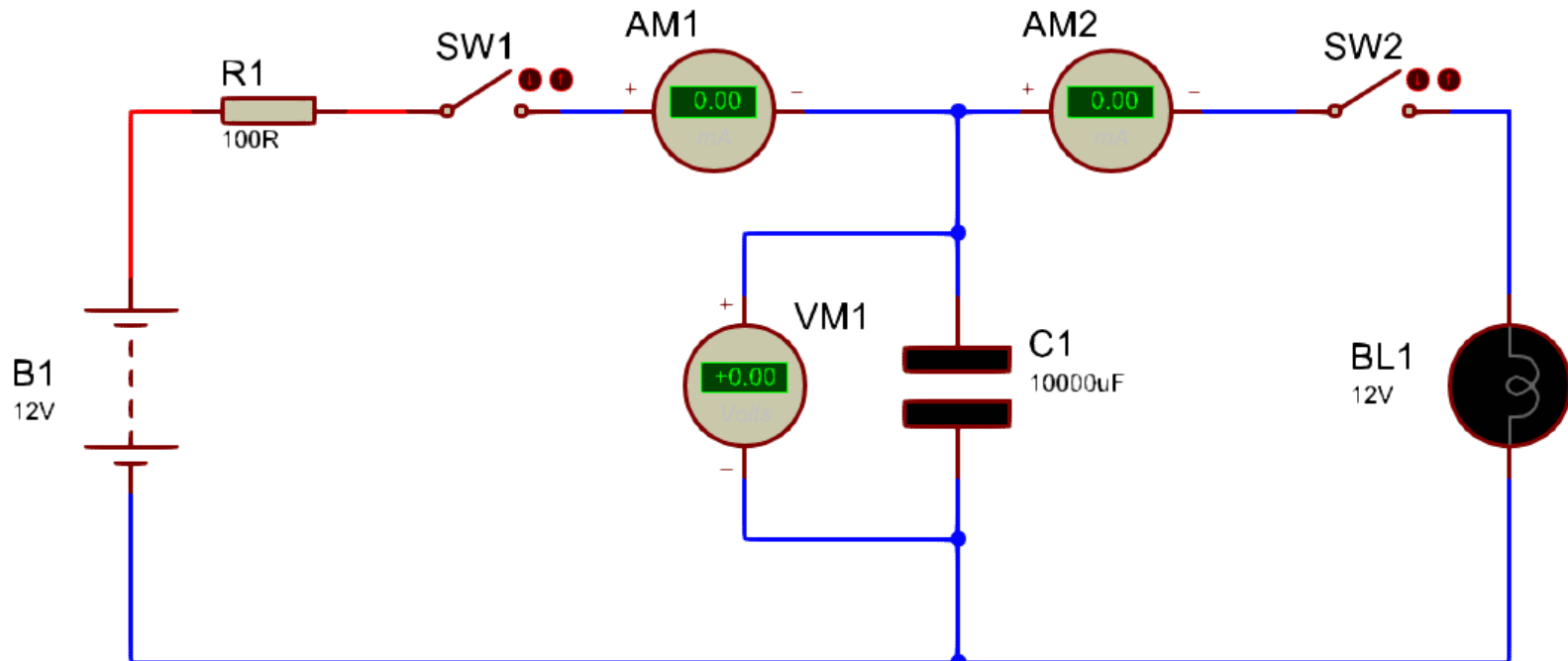
Non-polarized capacitors



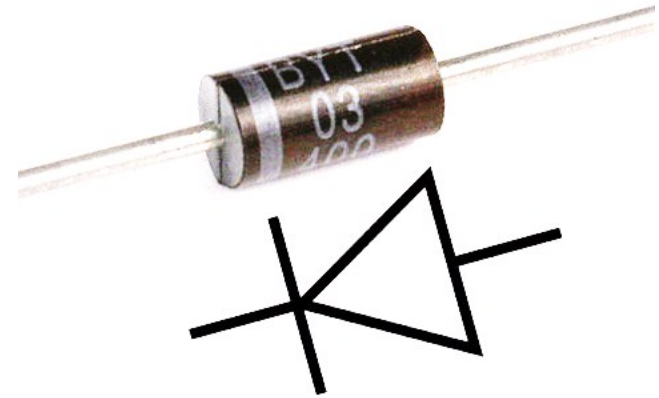
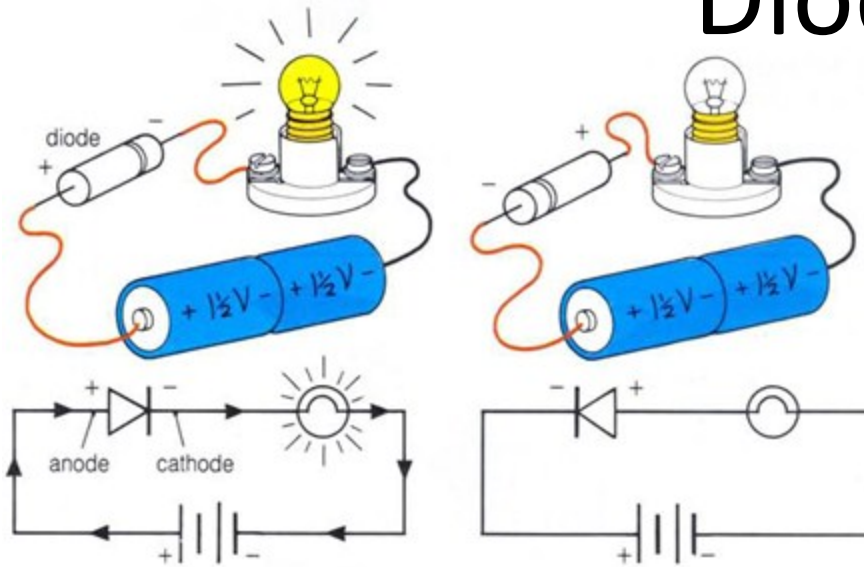
symbol for polarized capacitor



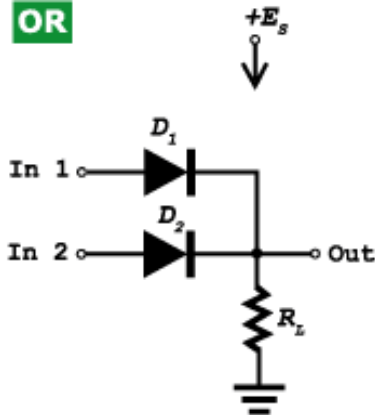
symbol for non-polarized capacitor



Diode



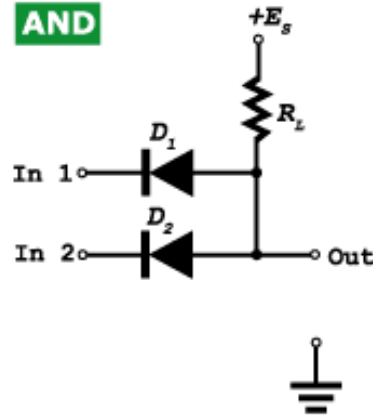
OR



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

0 - 0V
1 - Es

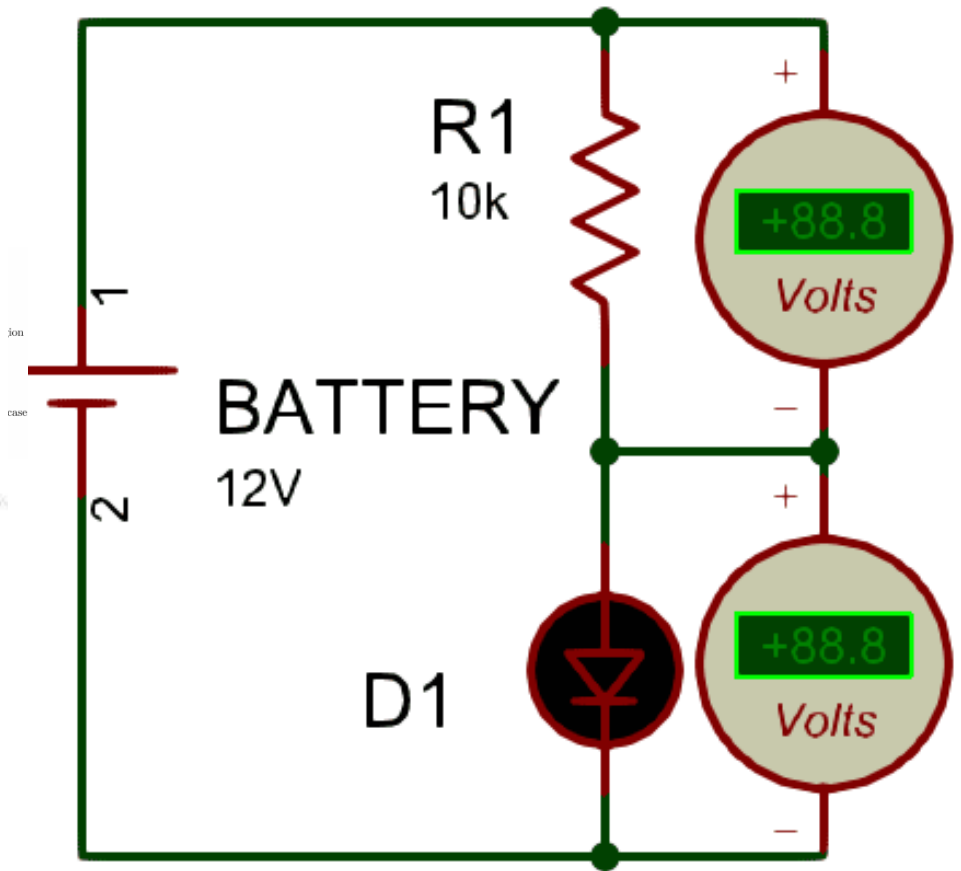
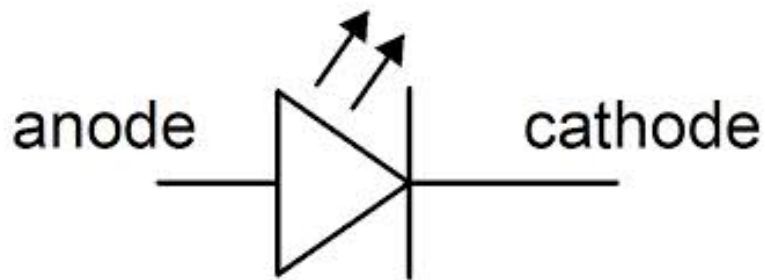
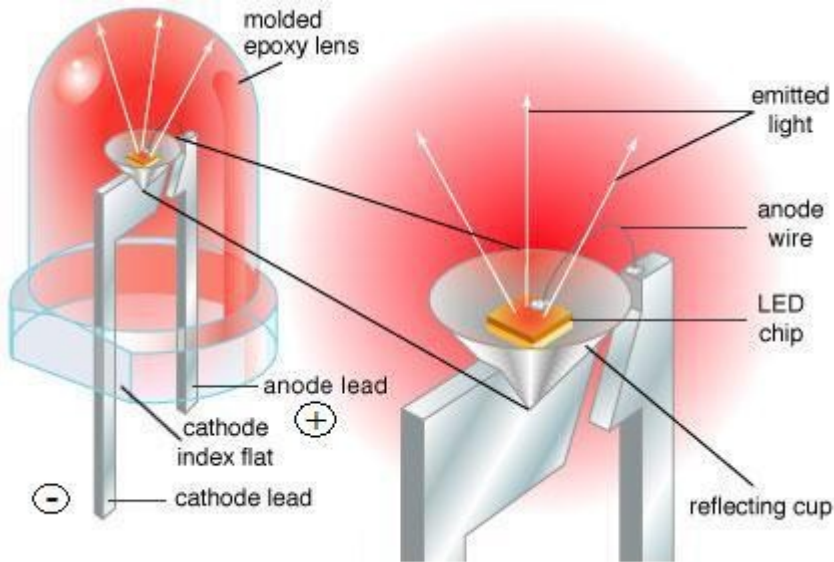
AND



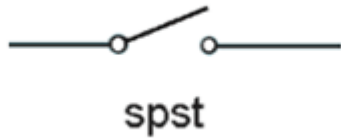
In 1	In 2	Out
0	0	0
0	1	0
1	0	0
1	1	1

Can we use a diode as voltage divider?

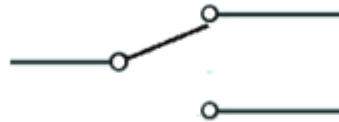
Light Emitting Diode (LED)



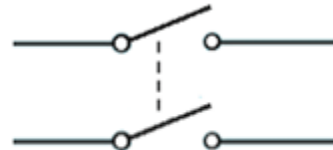
Switches



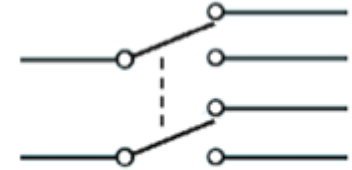
spst



spdt



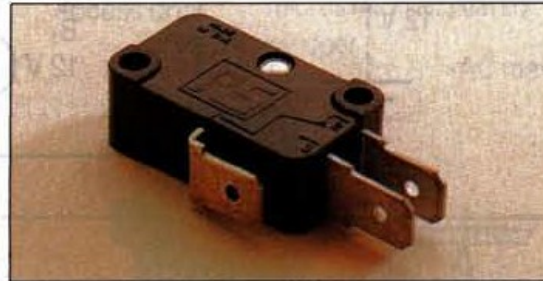
dpst



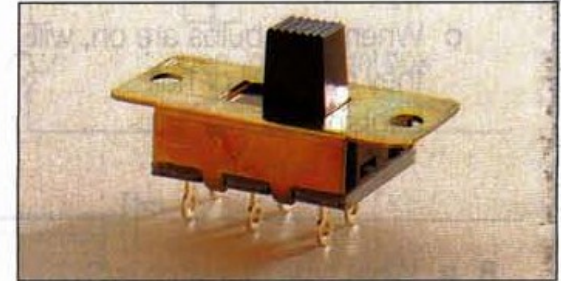
dpdt



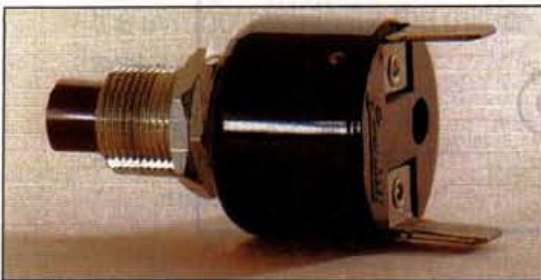
Toggle switch.



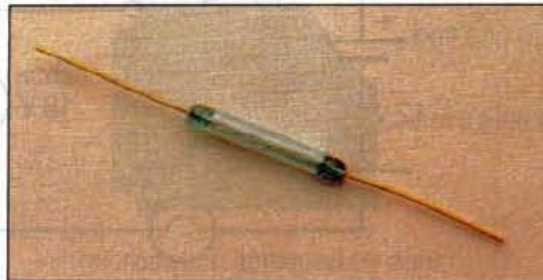
Microswitch



Slide switch



Push button switch

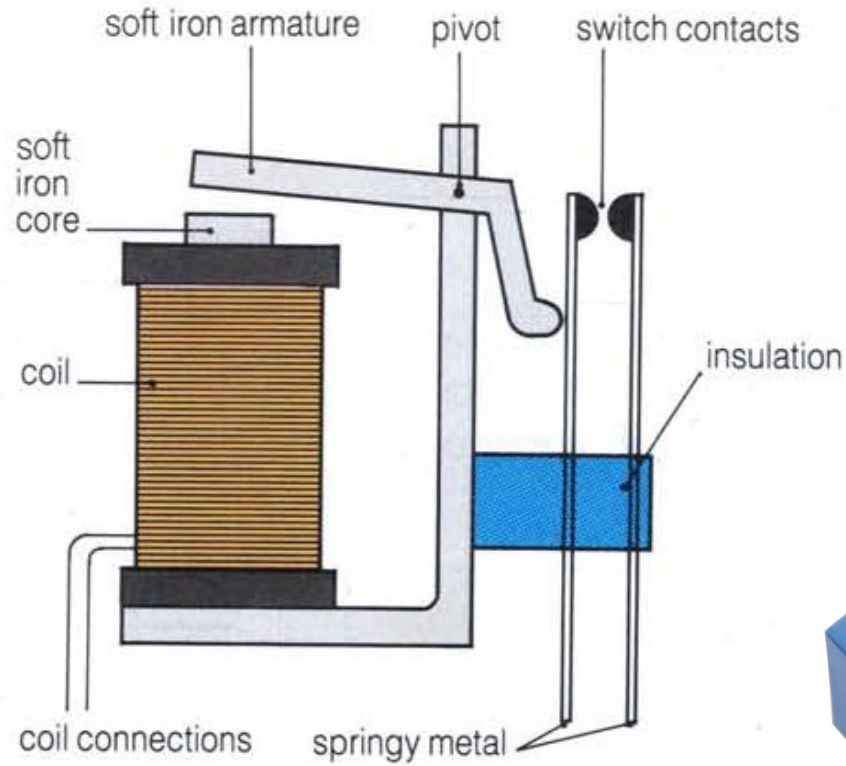


Reed switch

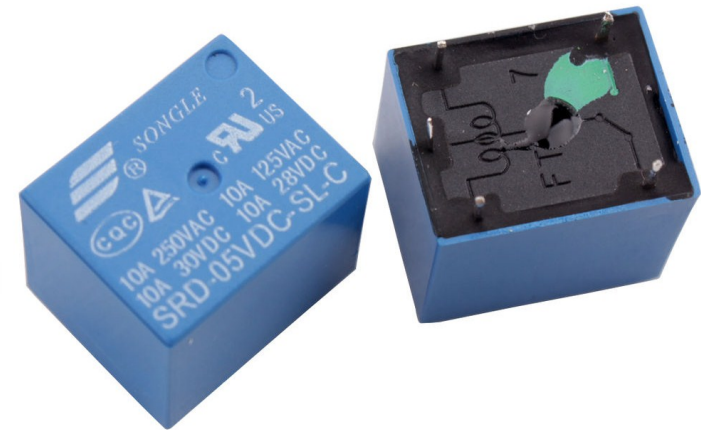
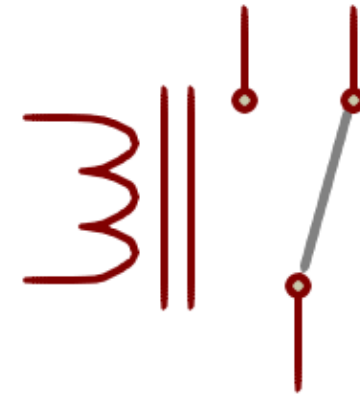


Rotary switch

Relay

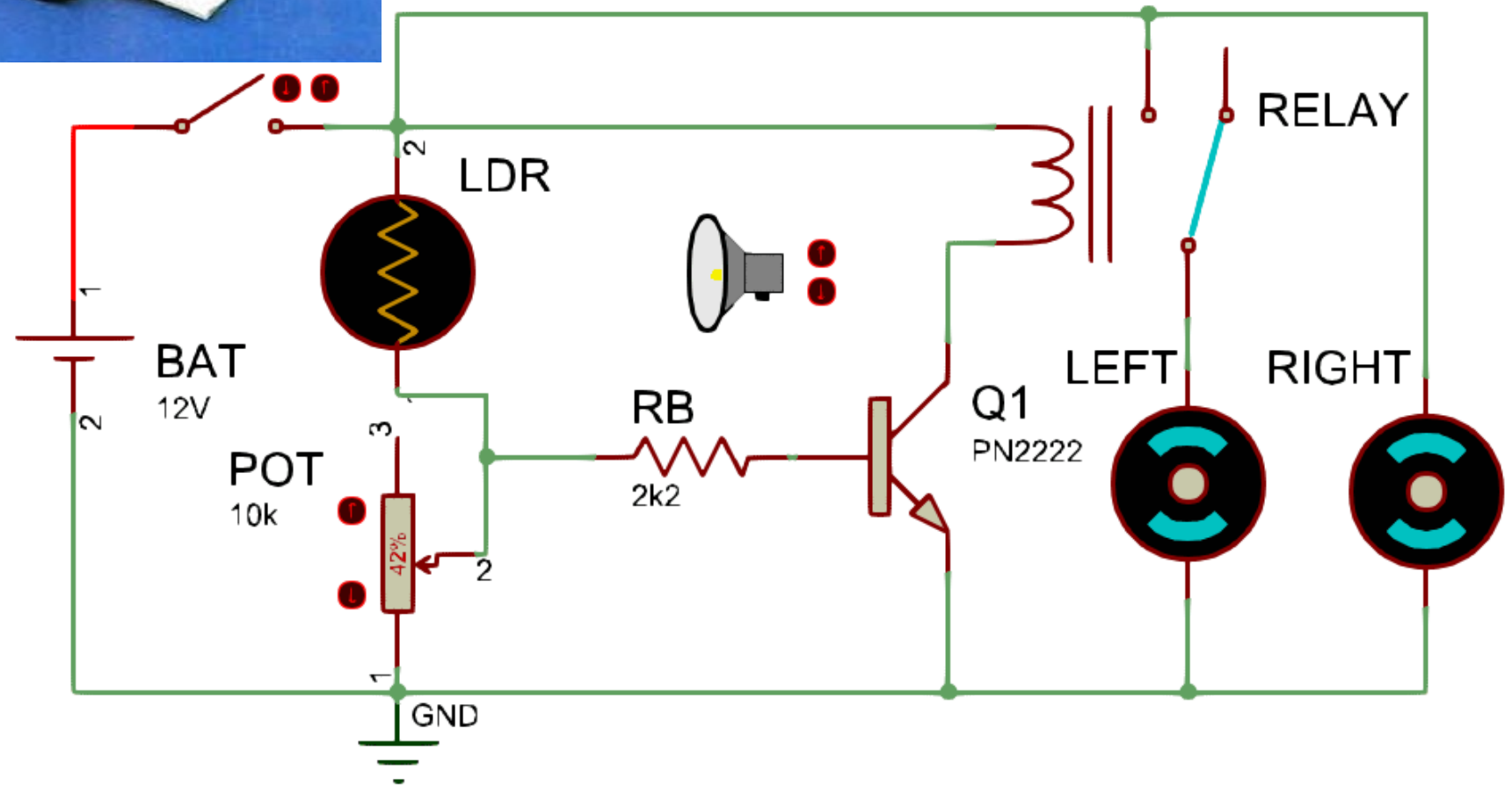
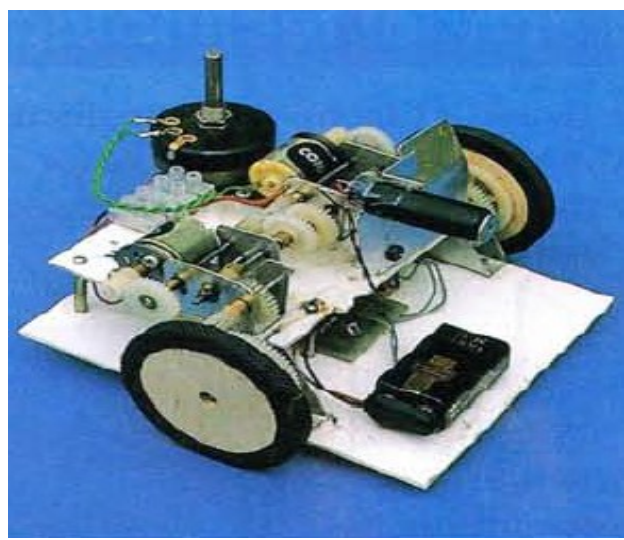


Construction of simple relay



What is the advantage of a relay over a transistor?

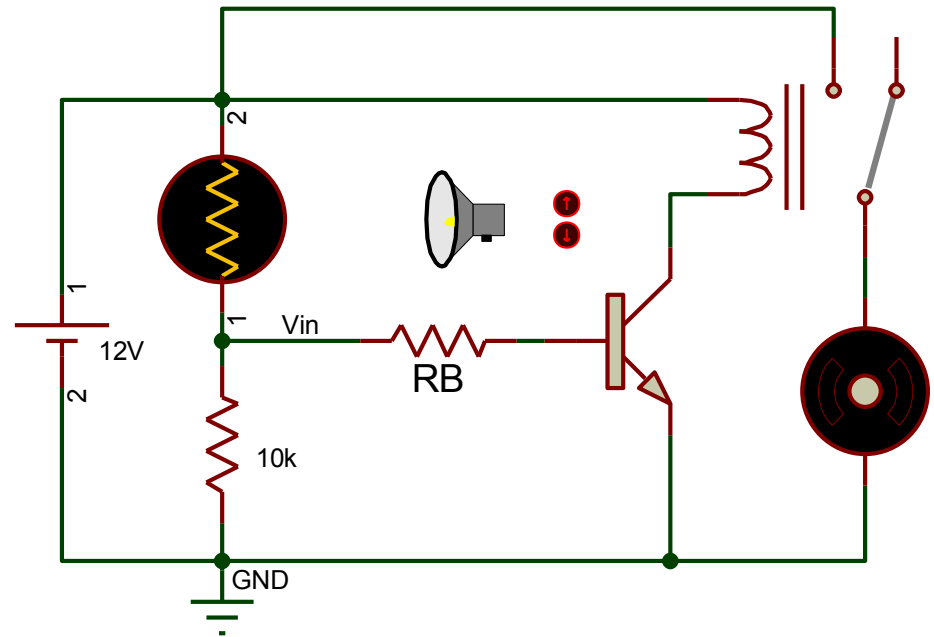
Relay Application



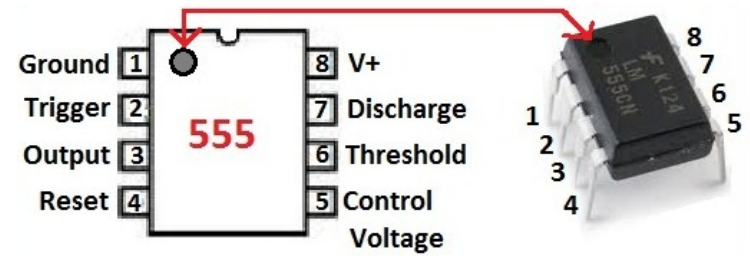
Lab Task 1(b)

The relay in the circuit turns on when 50mA 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



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

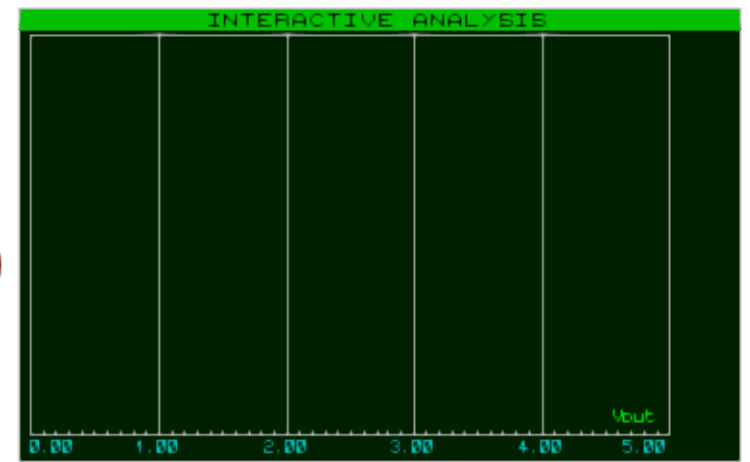
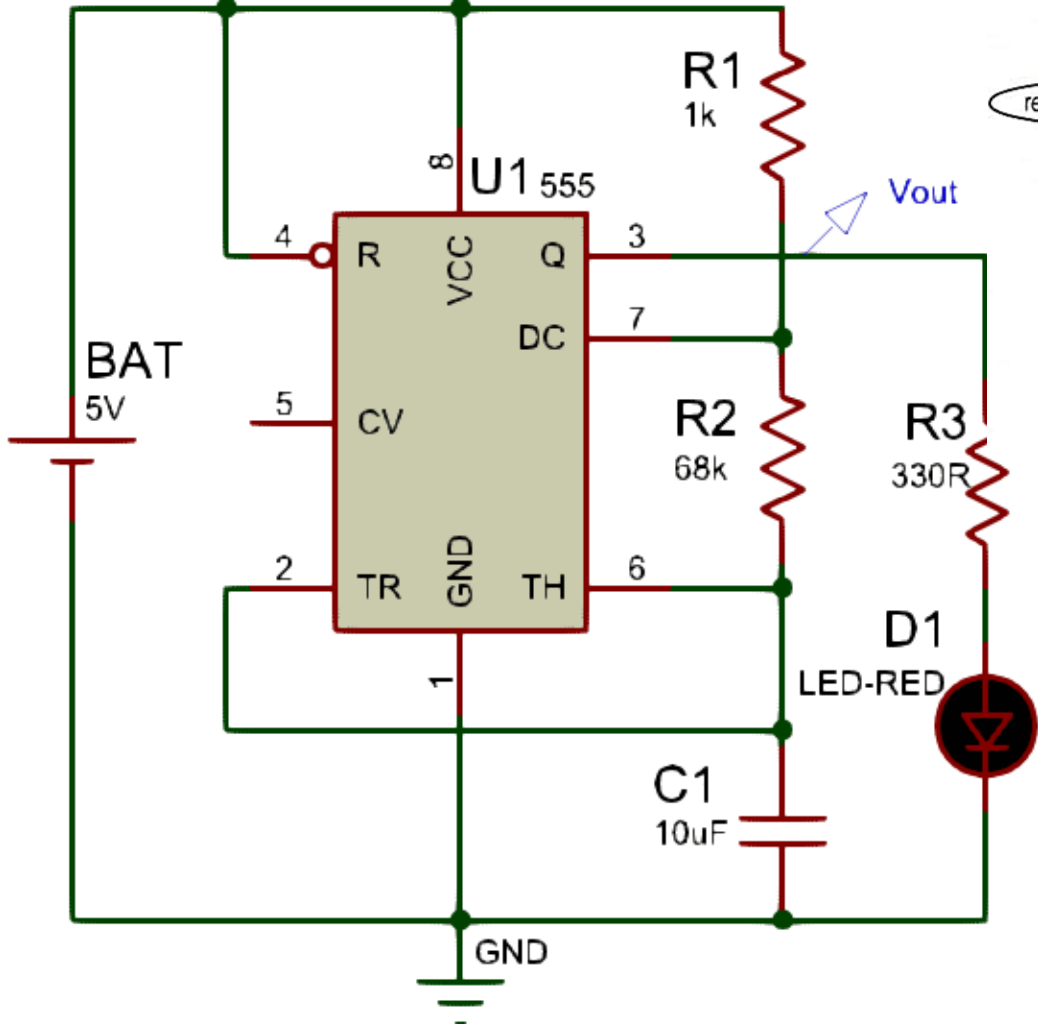
resistance in ohms capacitance in farads

For above example:

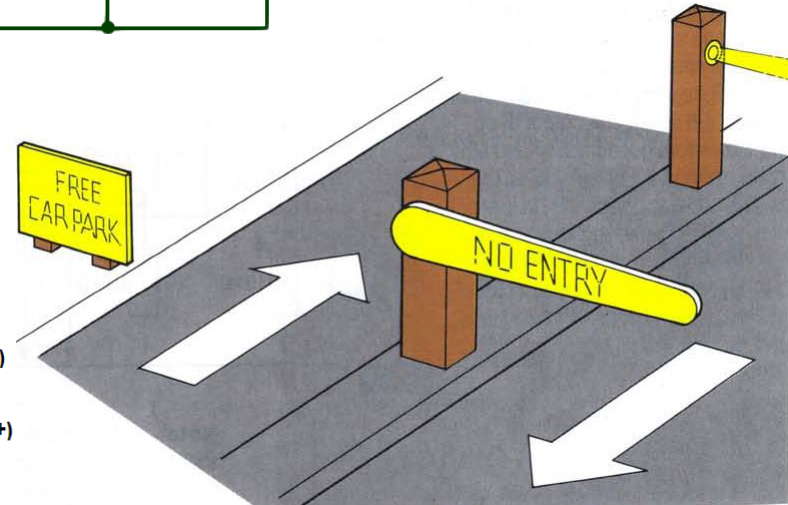
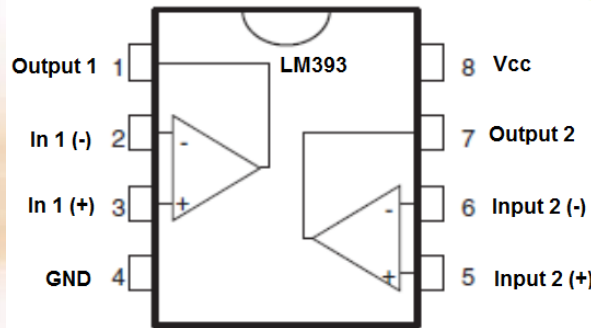
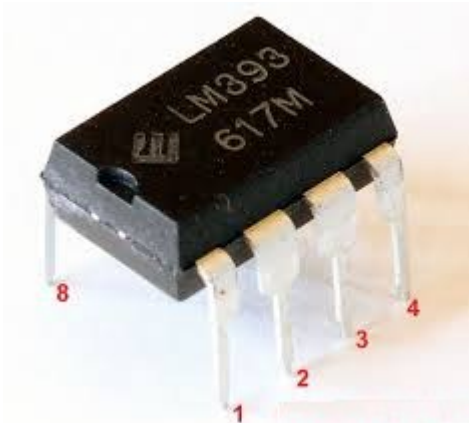
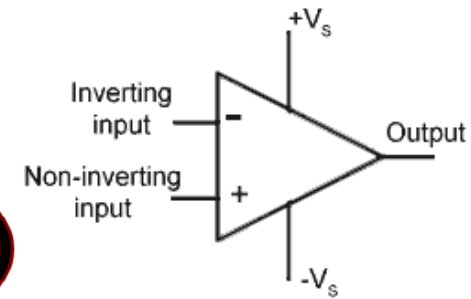
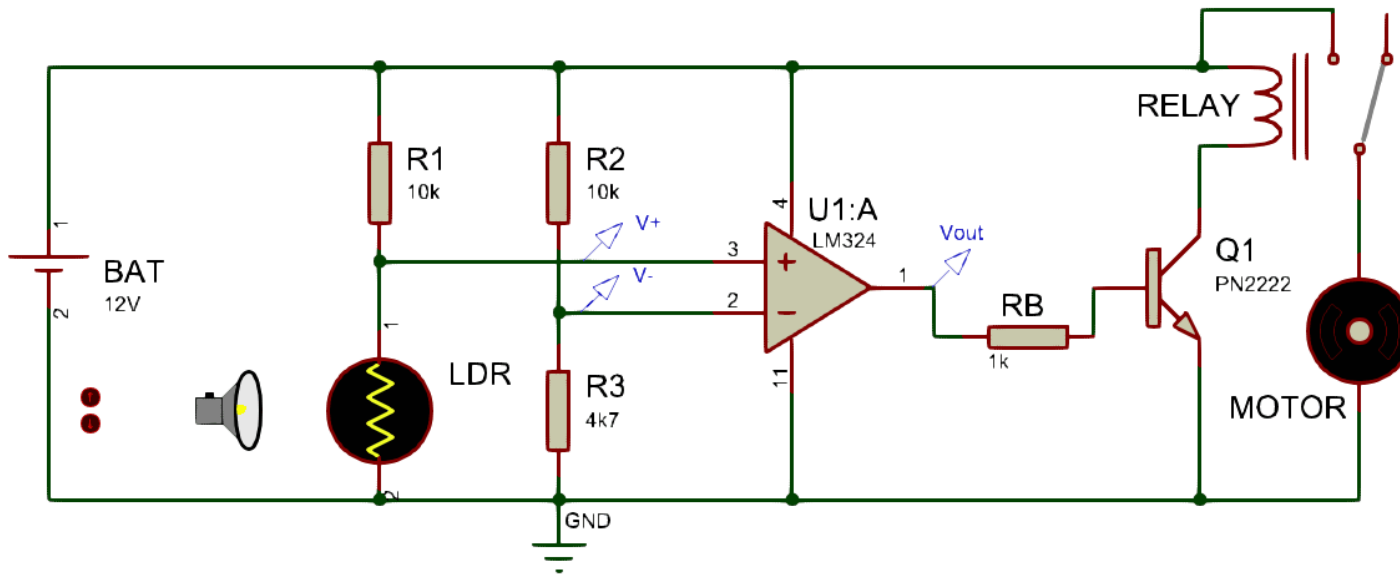
$$f = \frac{1.44}{(1000 + 2 \times 68000) \times 0.00001}$$

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

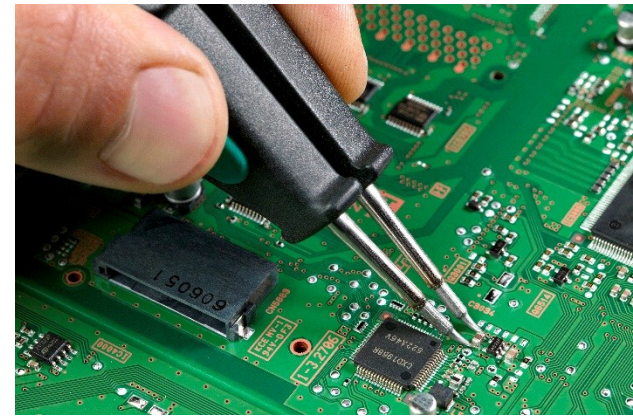
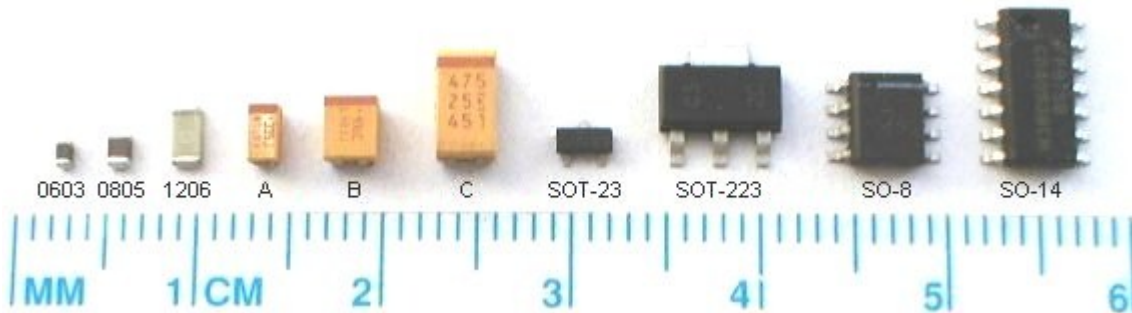
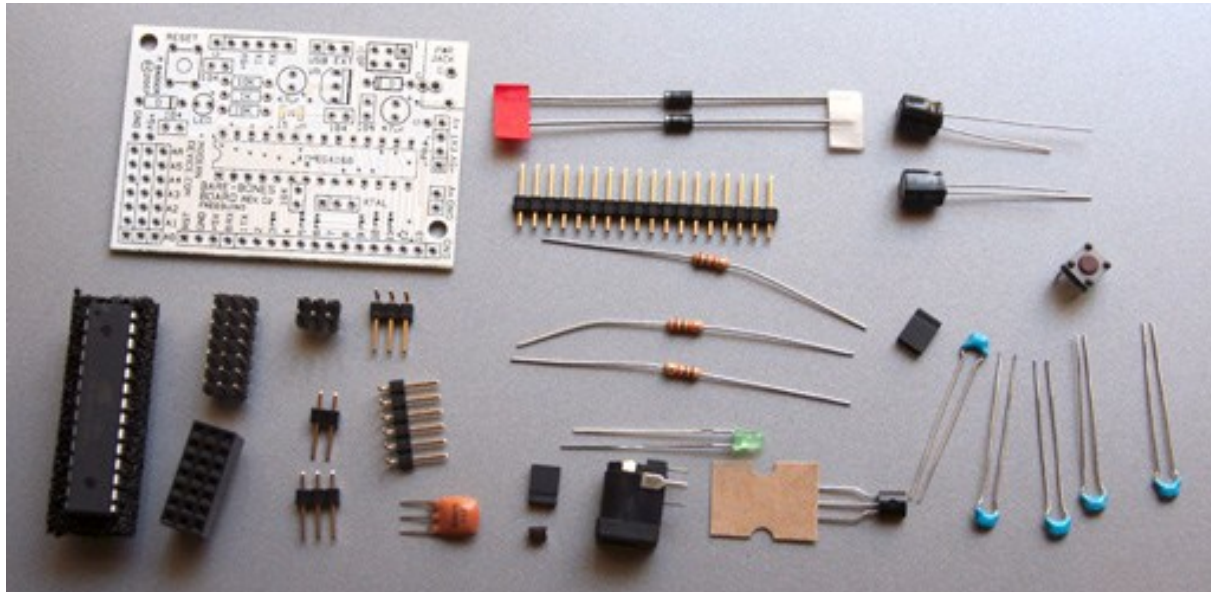
$$f = 1.05 \text{ Hz}$$



Operational Amplifier (Op-Amp)



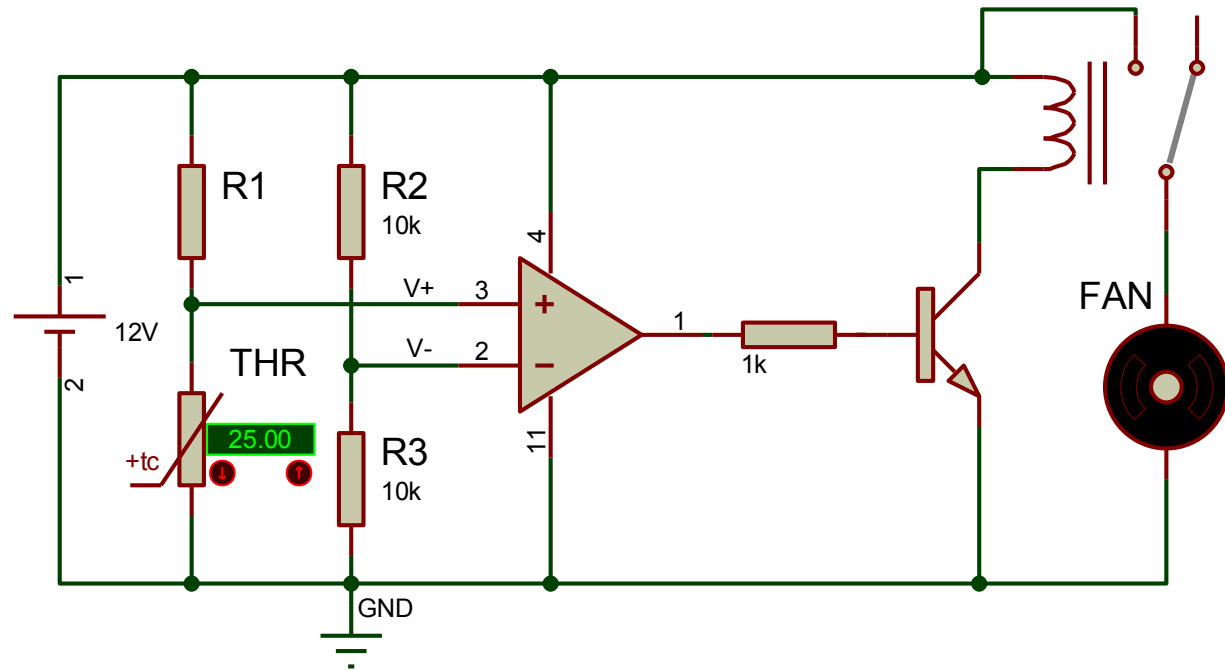
Through-Hole/SMD Components



Lab Task 1(c)

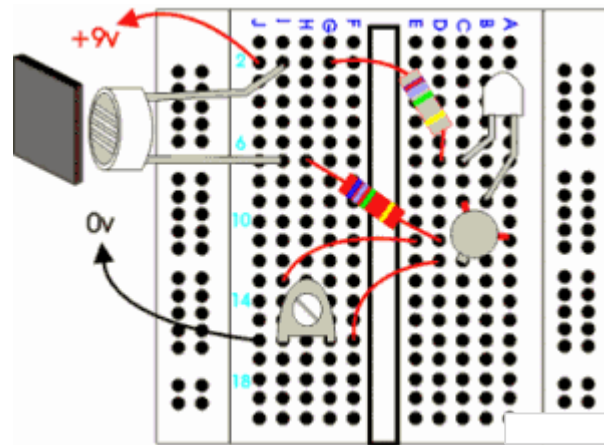
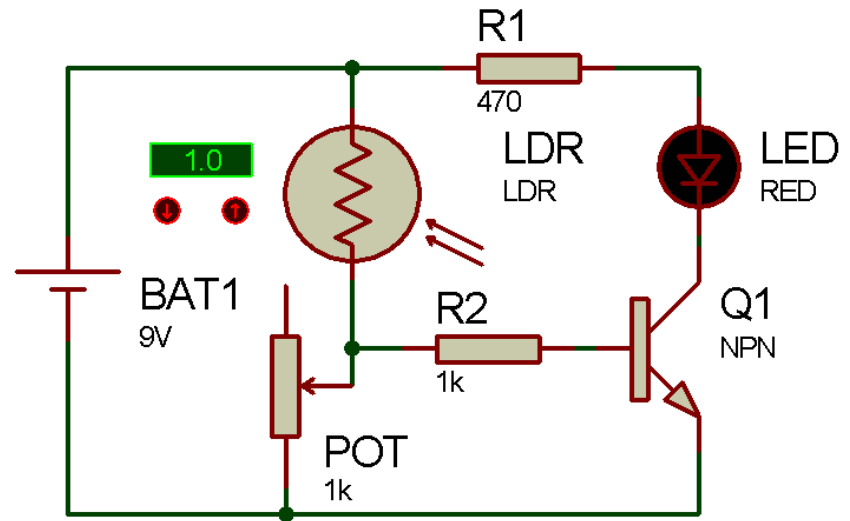
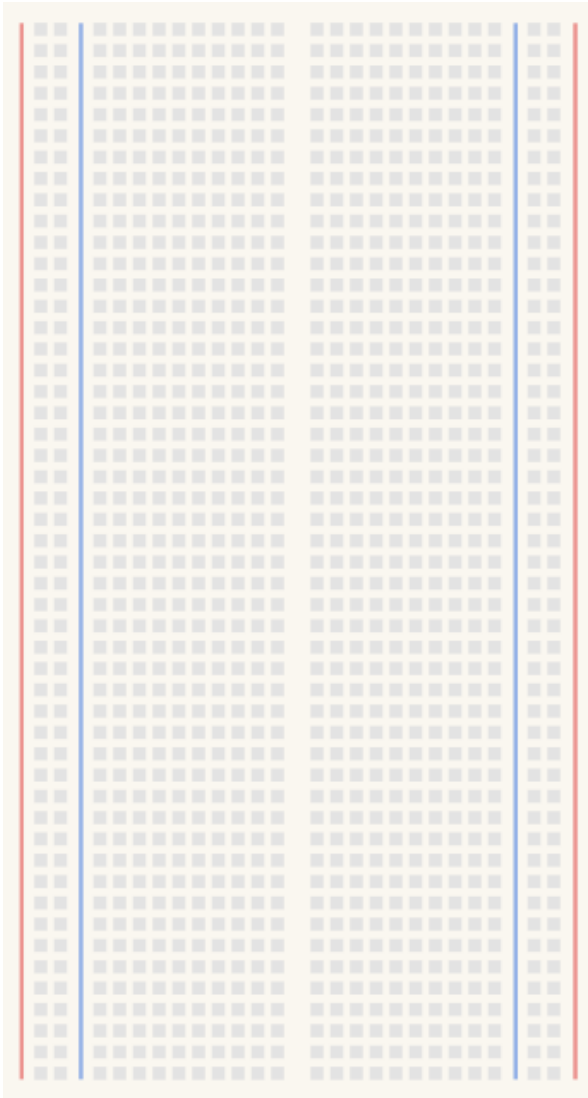
The following circuit uses thermistor and an op-amp to control the temperature of a room. The fan is required to maintain the room temperature at 25°C .

- 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°C ?

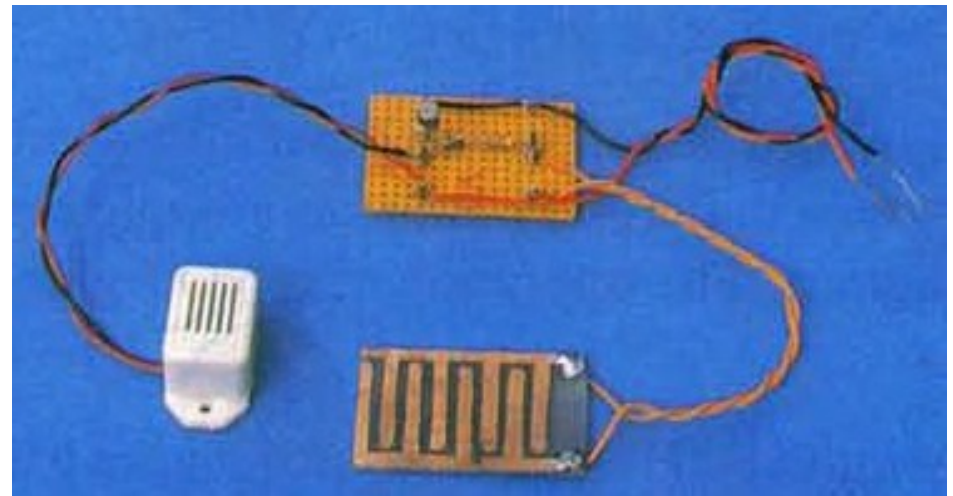
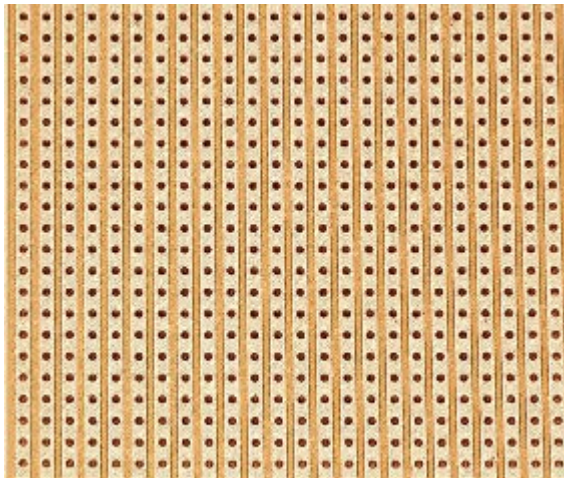
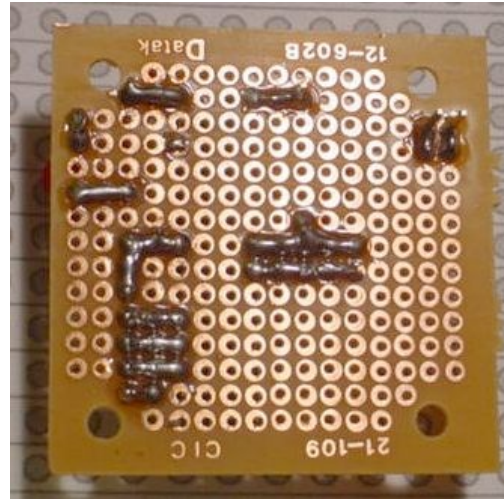
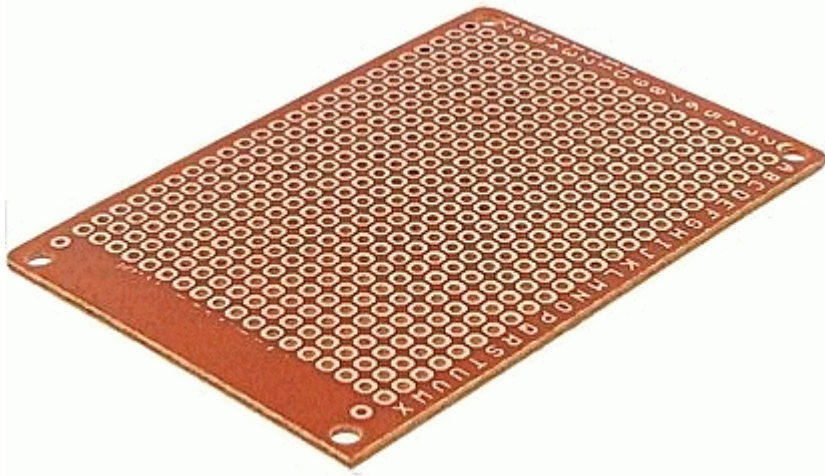


PCB PROTOTYPING CONVENTIONAL

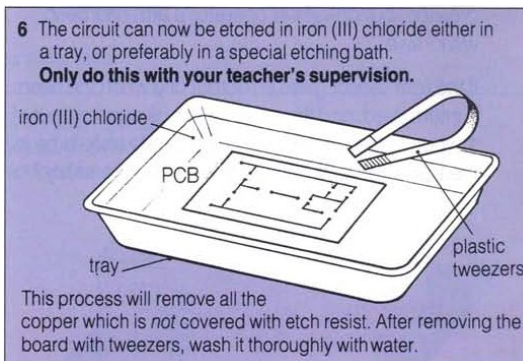
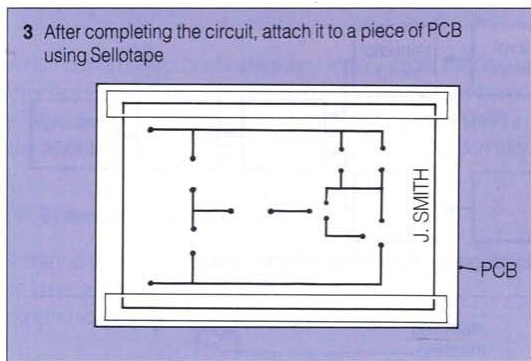
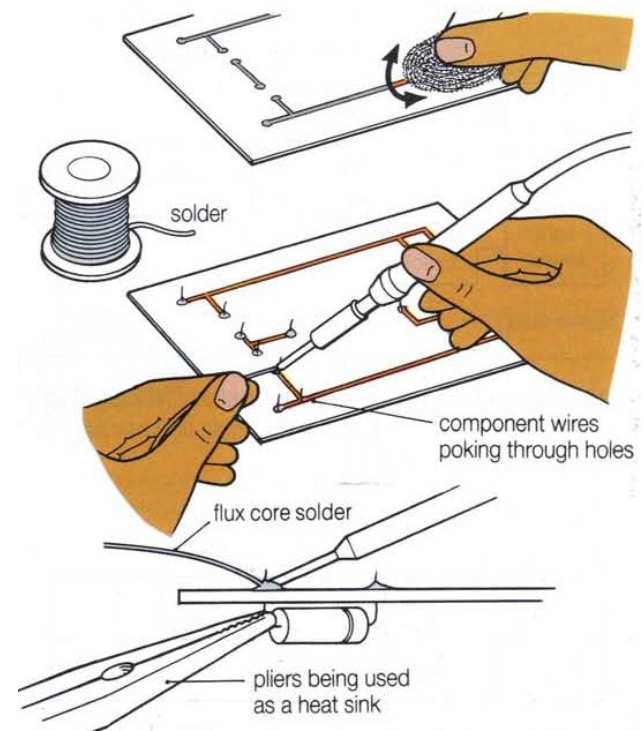
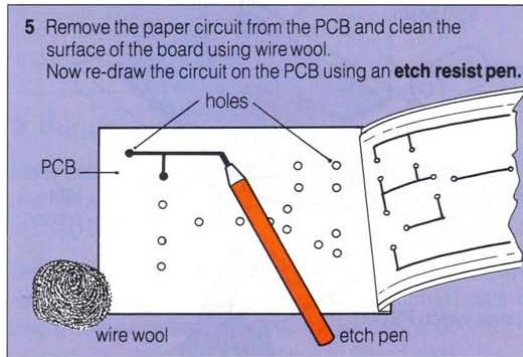
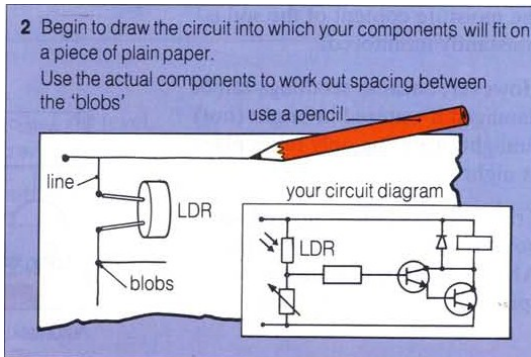
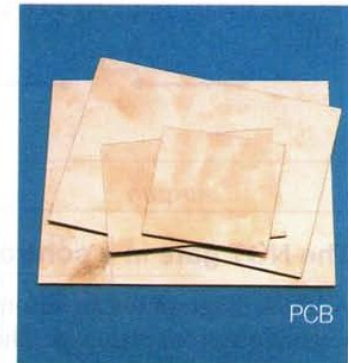
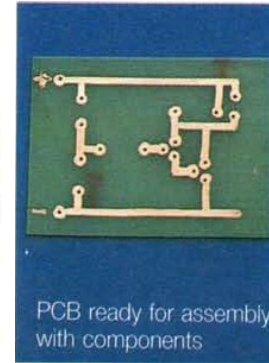
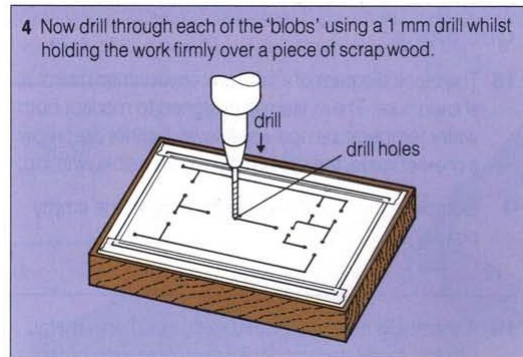
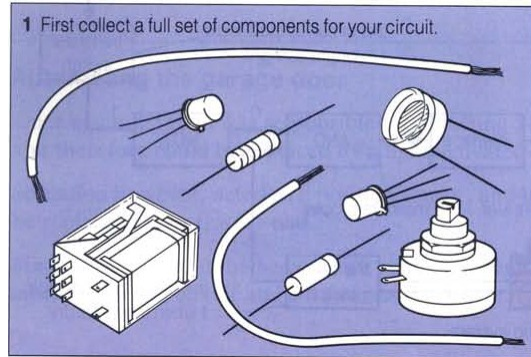
Bread Board



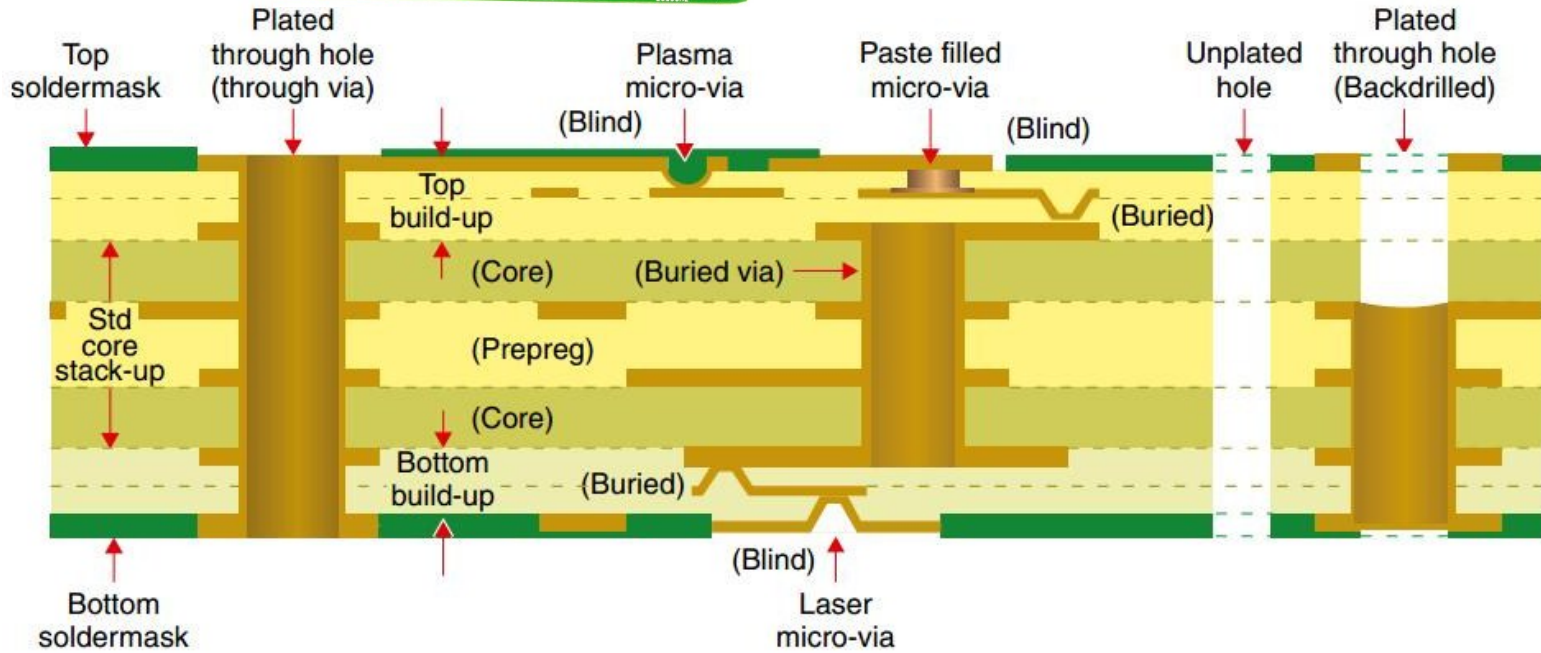
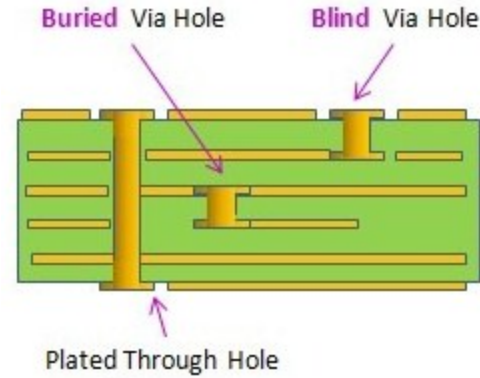
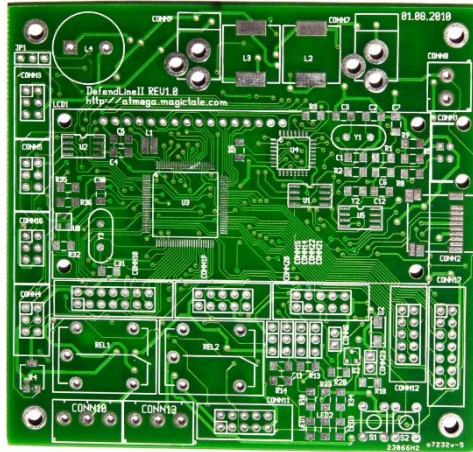
Vero Board (Matrix/Strip)



Single Layer PCB Prototyping Workflow



PCB Nomenclature

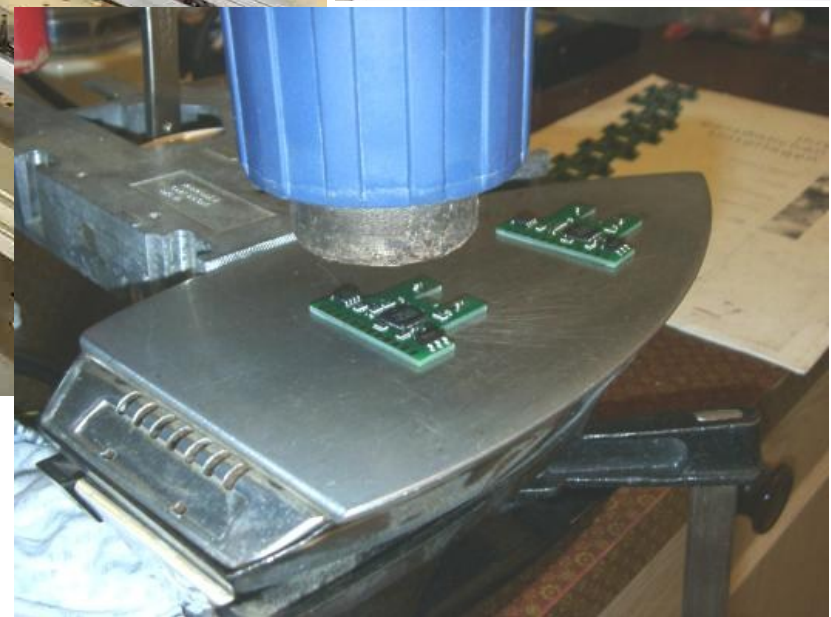


SMD Technology: Pick and Place Machine



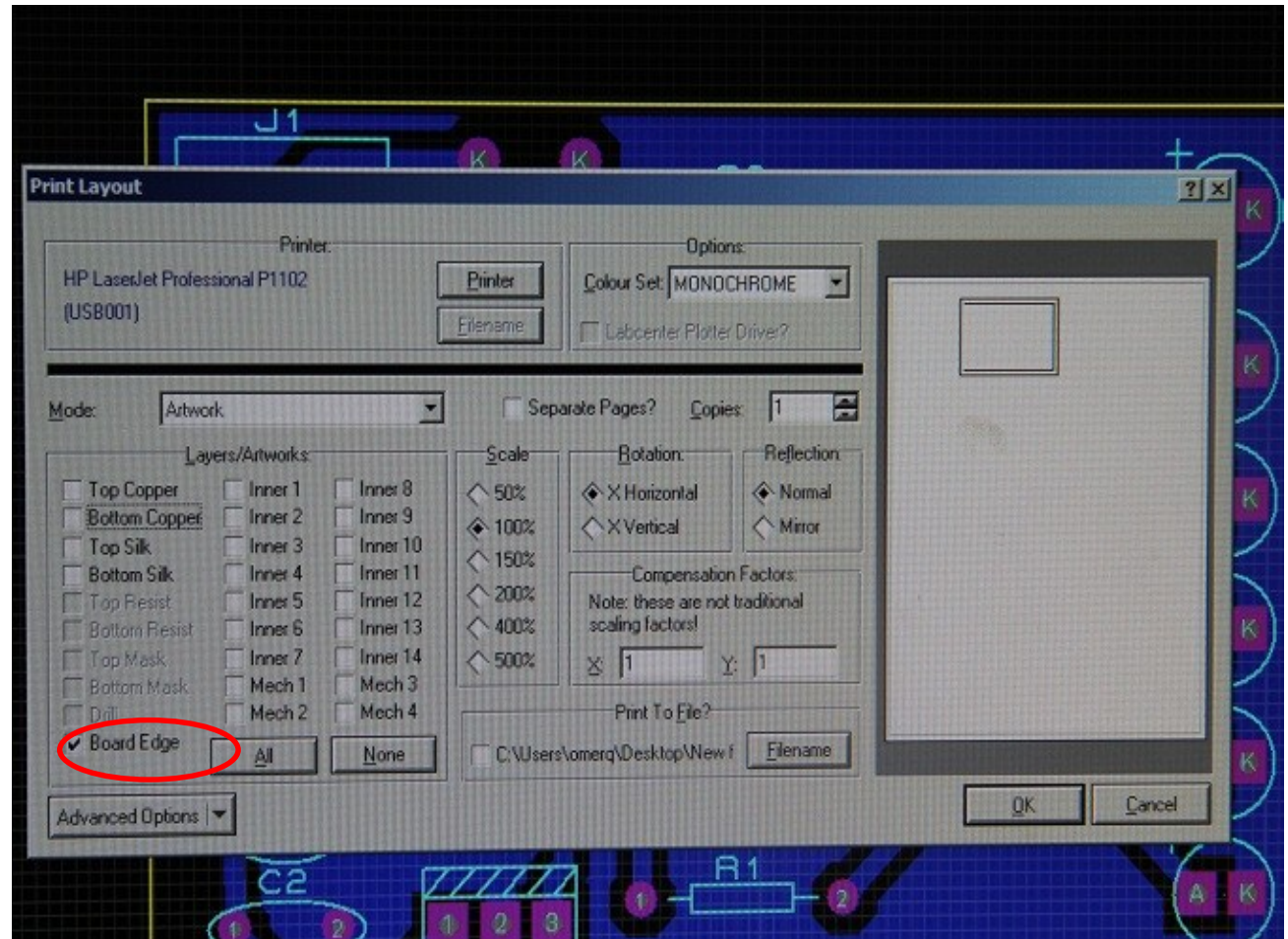
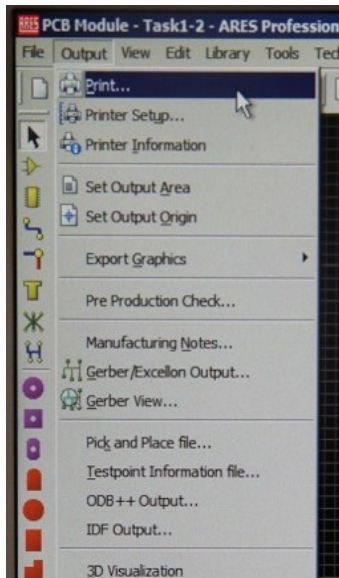
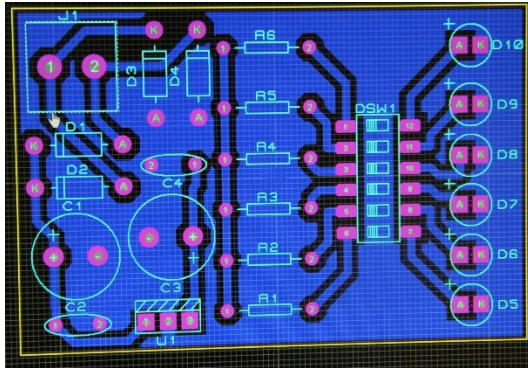
tonny@neodentech.com

SMD Technology: Reflow Oven



CONVENTIONAL PCB PROTOTYPING

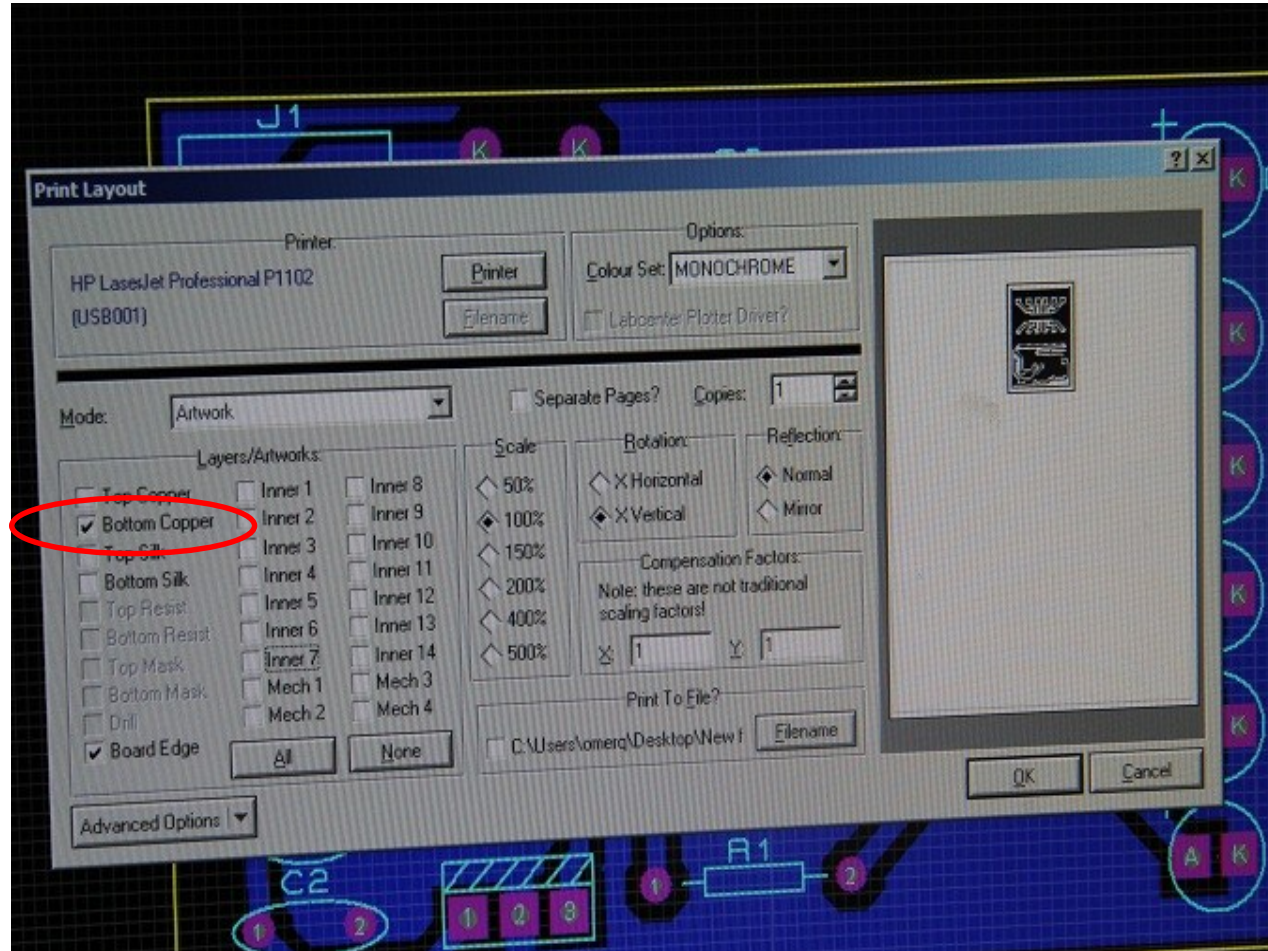
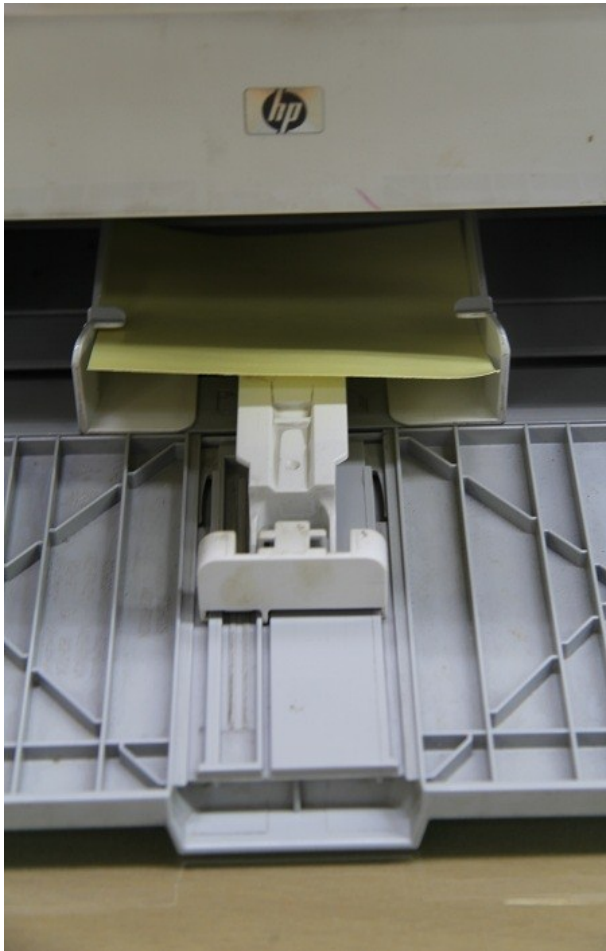
Print Outline for PCB Cutting



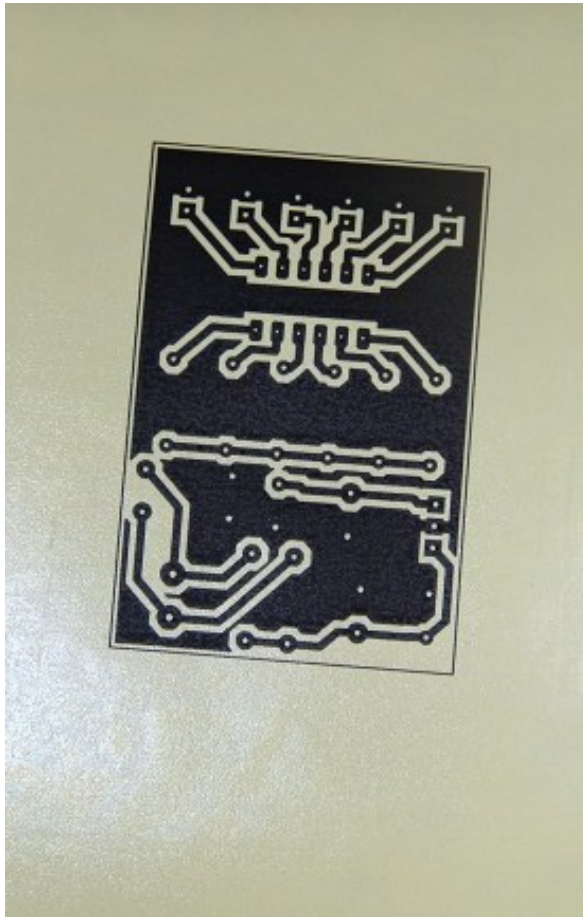
Cut Butter Paper / Peel Off Sticker Side



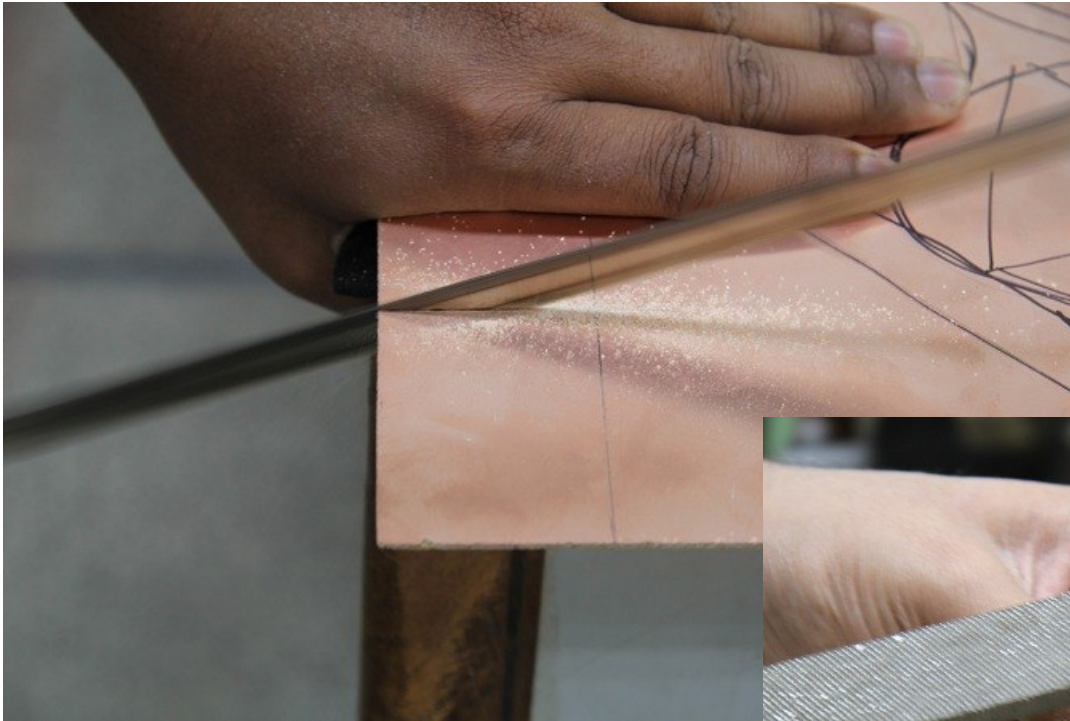
Print Layout using Laser Printer



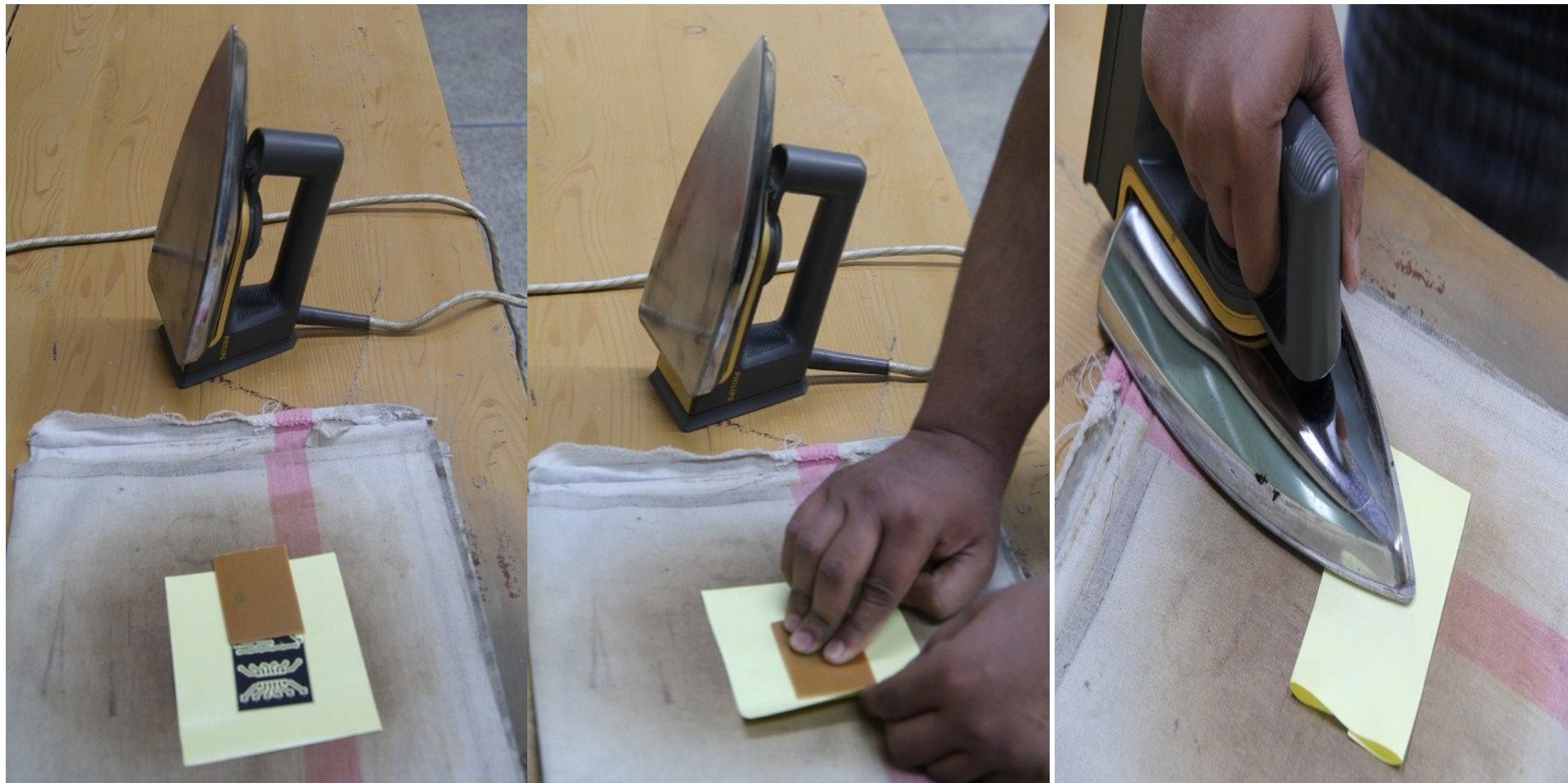
Negative Image of Printed Layout



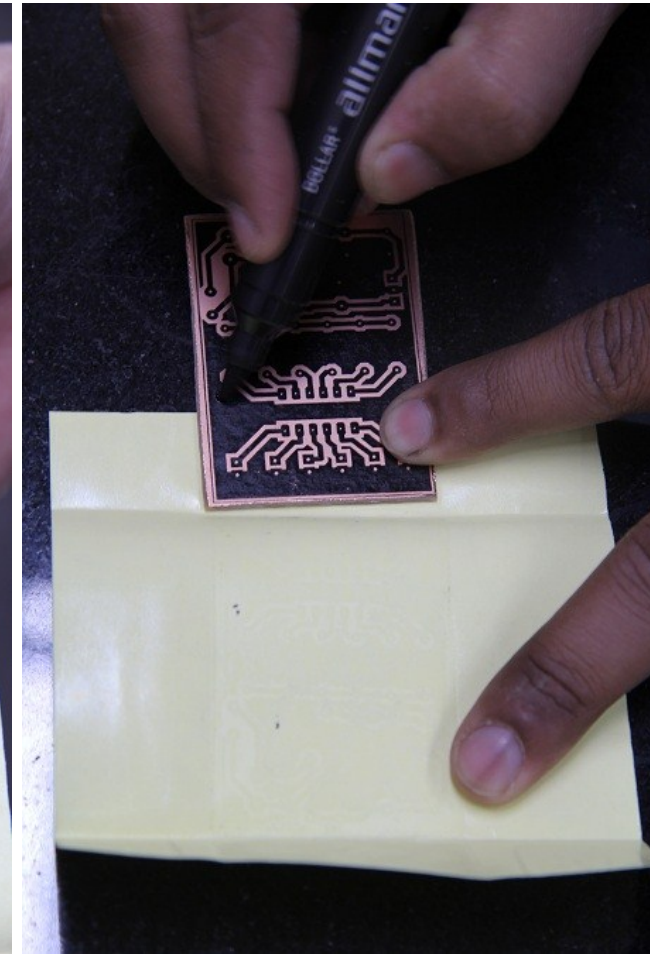
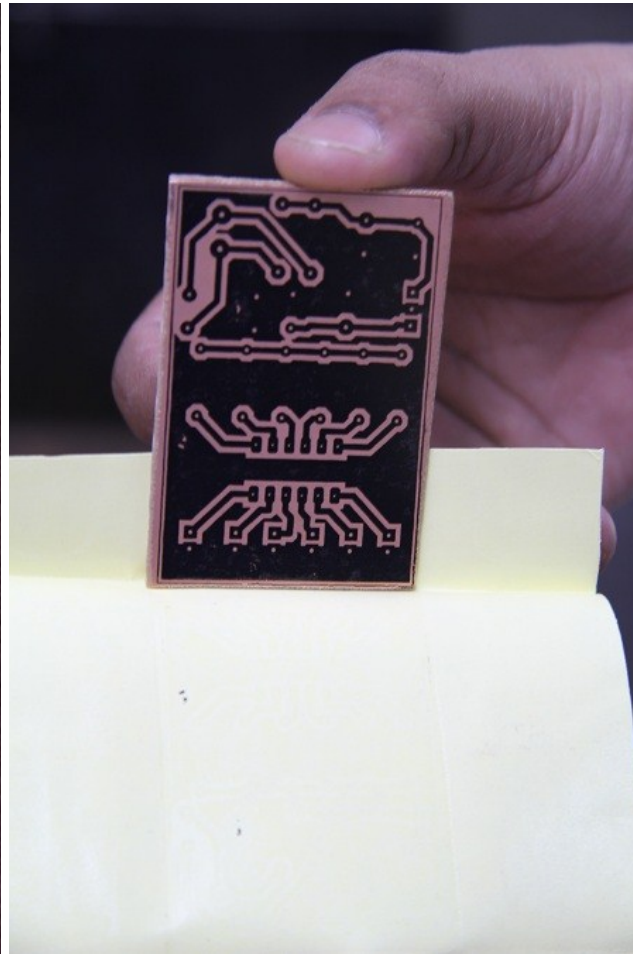
Cut/File PCB Board



Transfer Layout Image on PCB



Ink Transferred on PCB



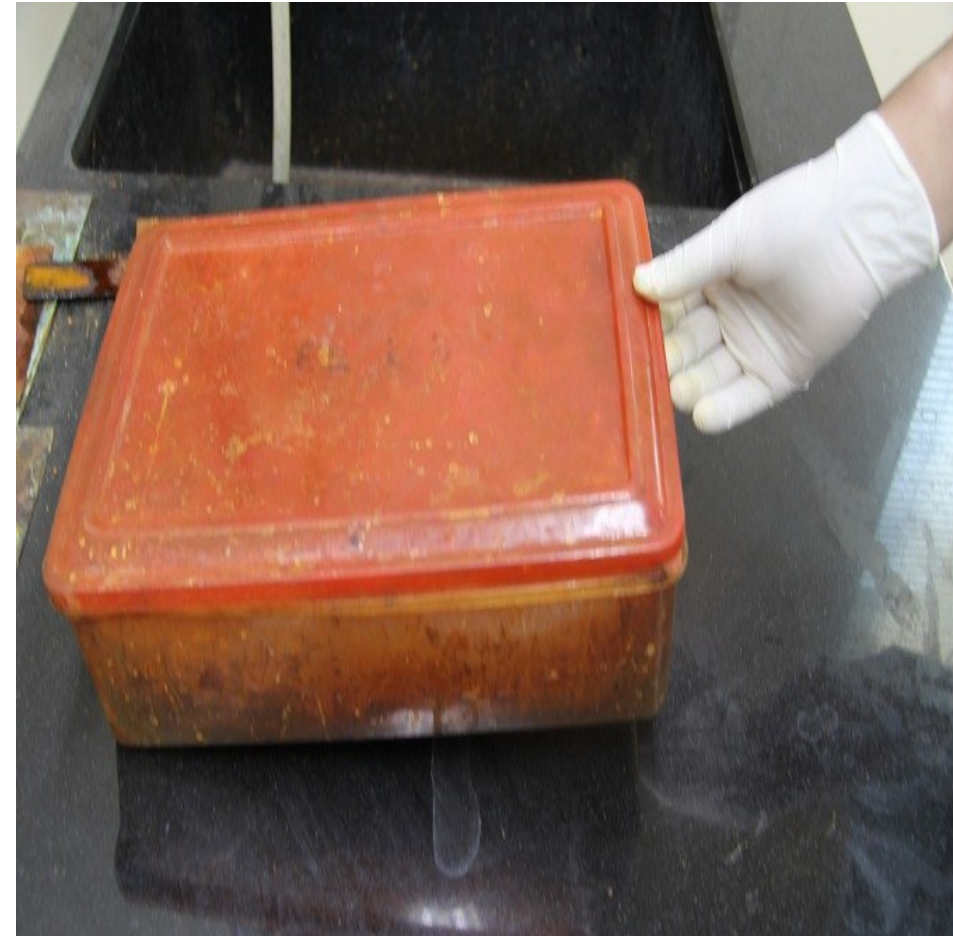
Use Hot Water and FeCl₃



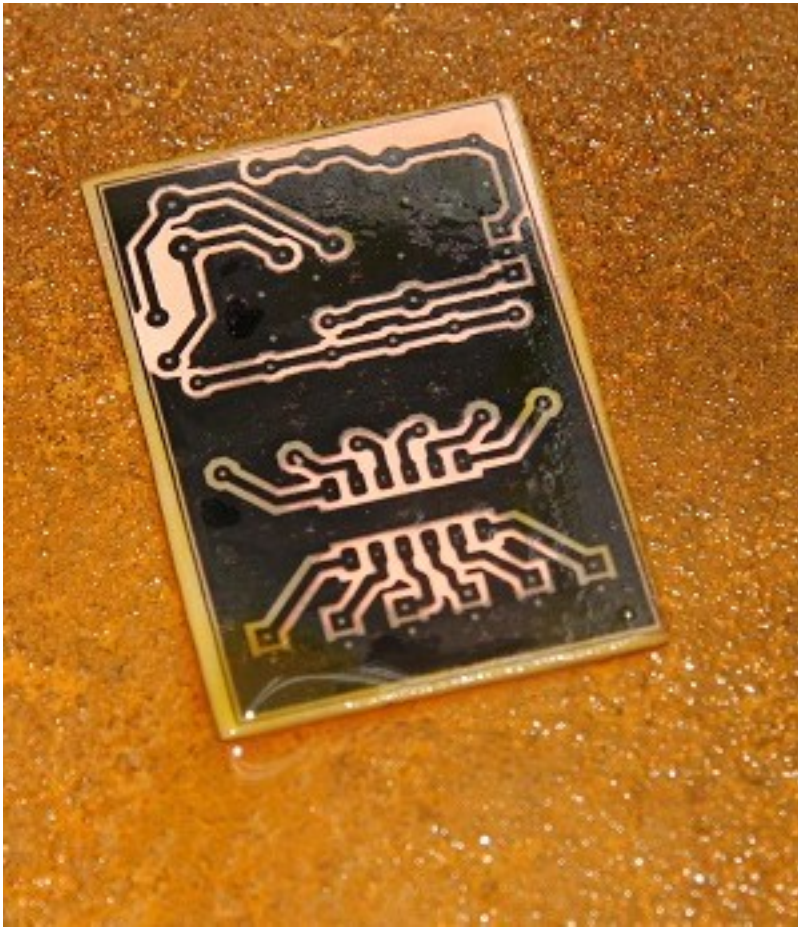
FeCl₃ and PCB Inside Etching Tank



Add boiling water into the tank and stir the solution



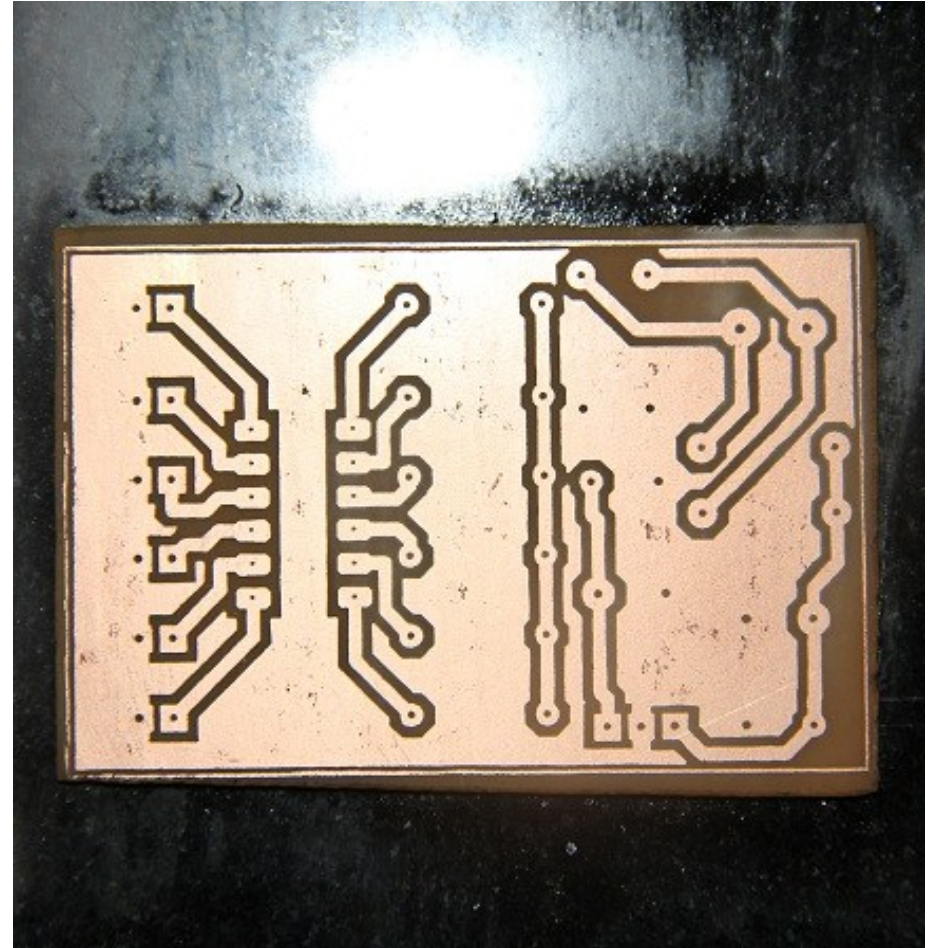
Exposed copper is being dissolved into FeCl_3 solution



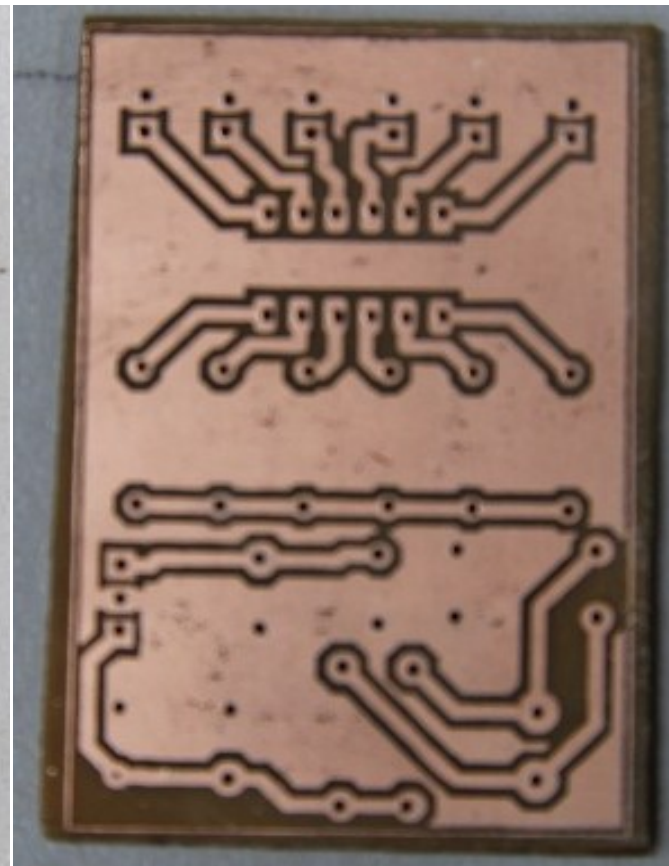
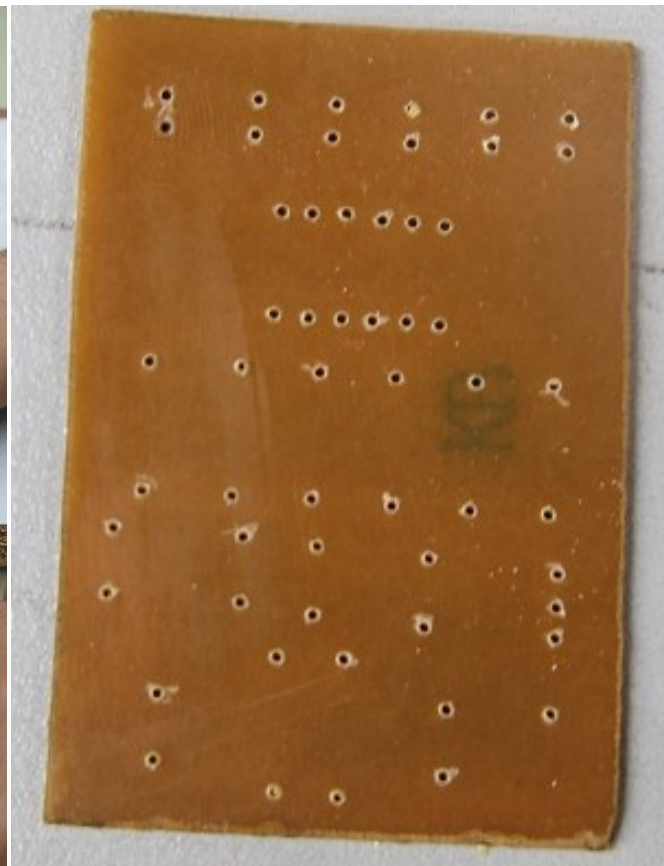
Wash after Etching



Use Petrol to remove Printer Ink from Etched PCB



Hand Drilling



Prepare Butter Paper for Silk Screen Printing



Bottom Copper

Top Silk

Bottom Silk

Top Resist

Bottom Resist

Top Mask

Bottom Mask

Drill

Board Edge

Inner 2

Inner 3

Inner 4

Inner 5

Inner 6

Inner 7

Mech 1

Mech 2

Inner 8

Inner 9

Inner 10

Inner 11

Inner 12

Inner 13

Inner 14

Mech 3

Mech 4

Options:

Printer

Filename

Colour Set: MONOCHROME

Labcenter Plotter Driver?

Separate Pages? Copies: 1

Scale: 50%, 100%, 150%, 200%, 400%, 500%

Rotation: X Horizontal, X Vertical

Reflection: Normal, Mirror

Compensation Factors: X: 1, Y: 1

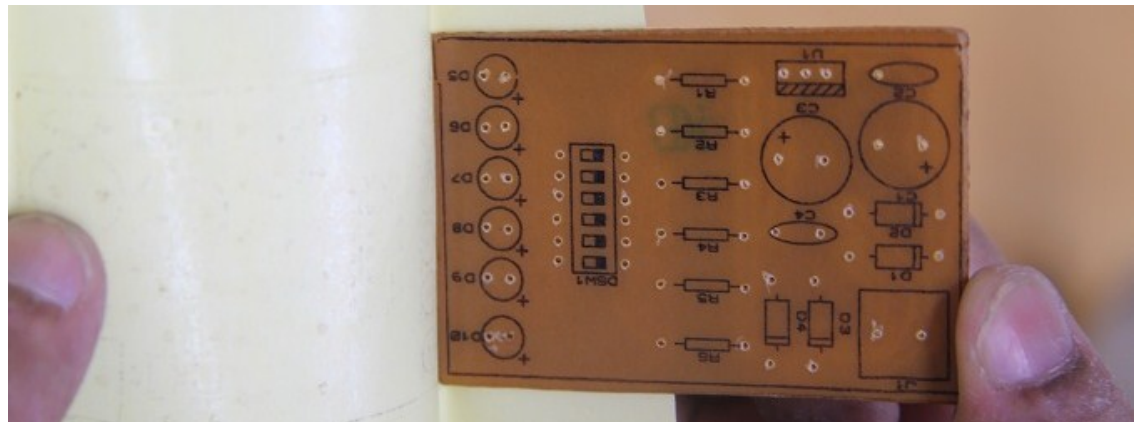
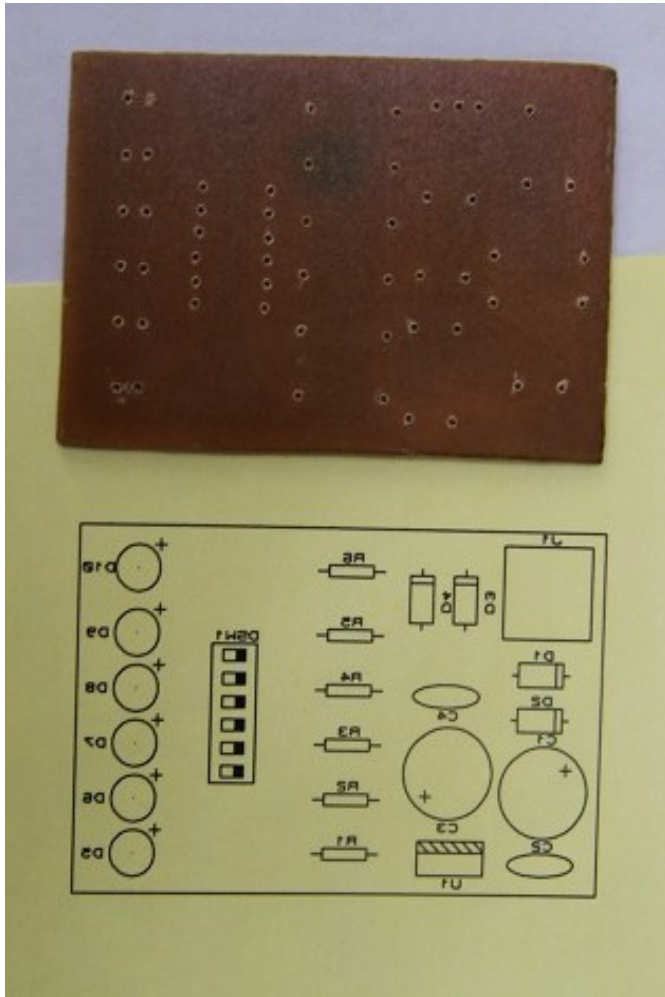
Print To File? C:\Users\omerg\Desktop\New f

Filename

OK Cancel

Advanced Options

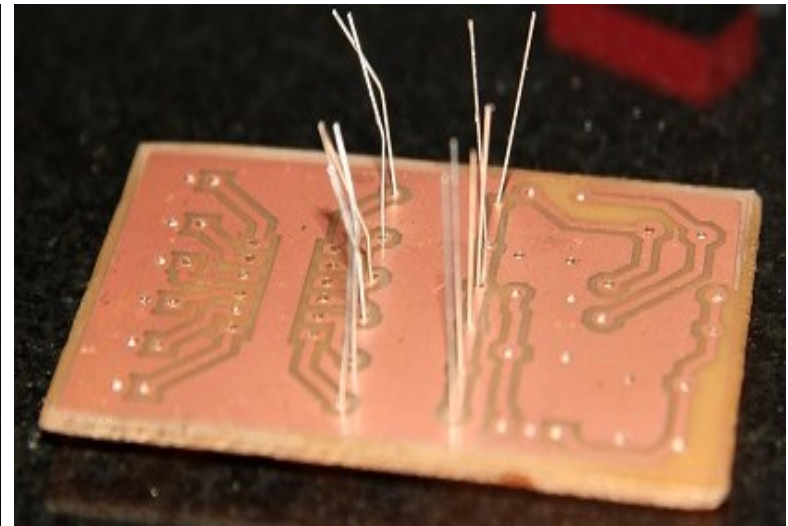
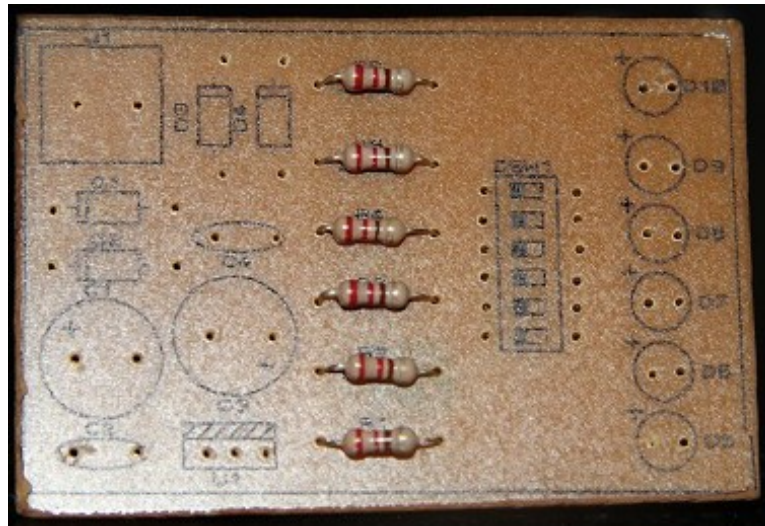
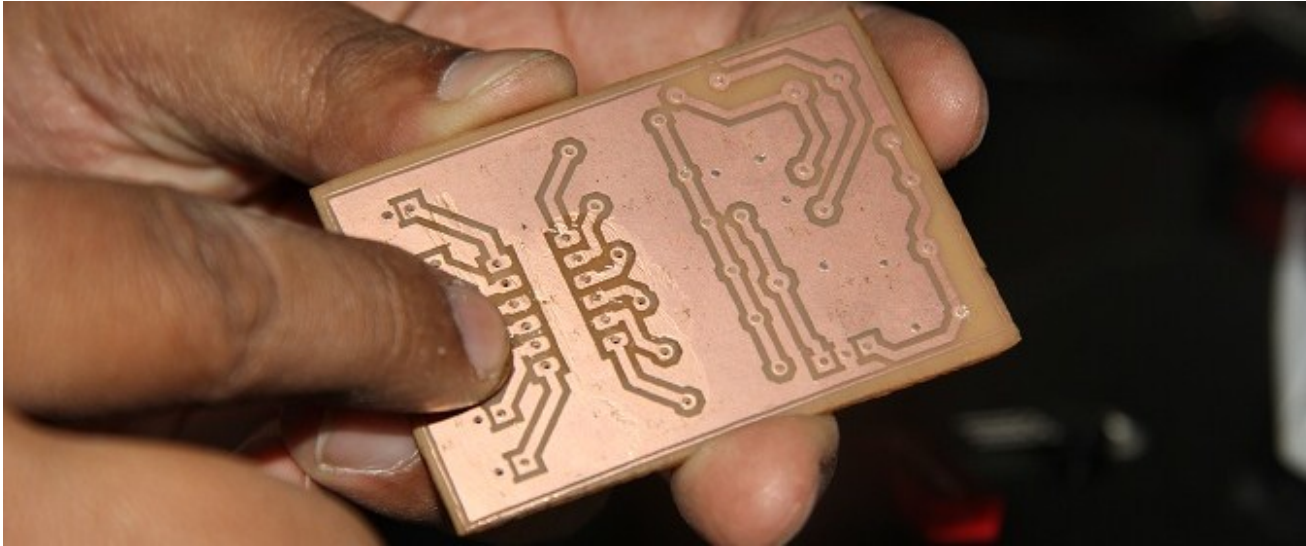
Transfer Silk Screen on PCB



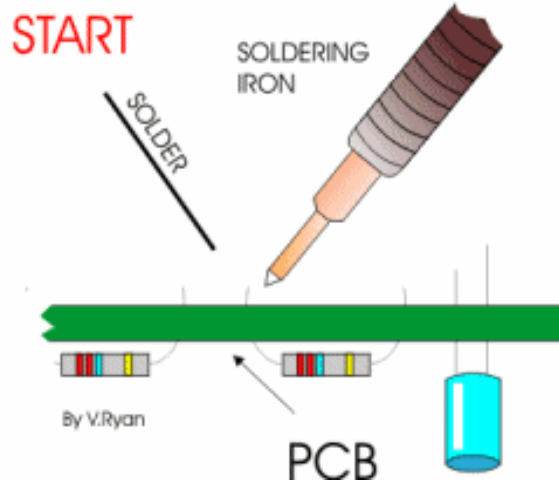
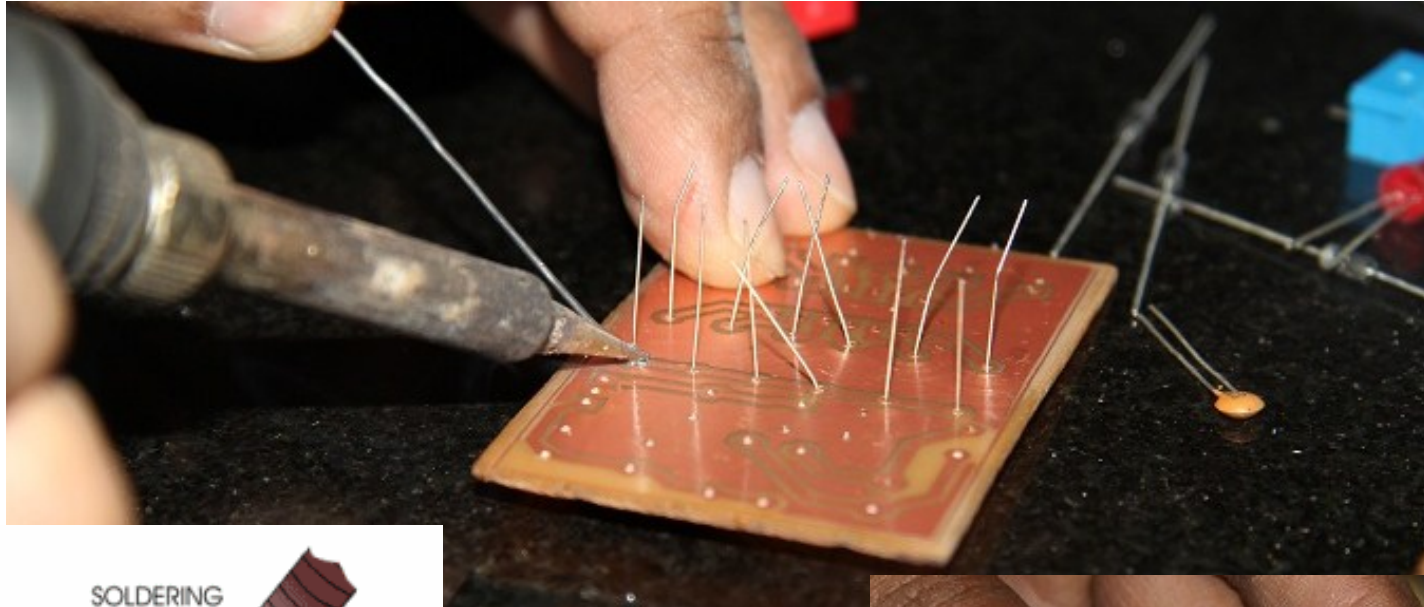
Prepare Soldering Work Station



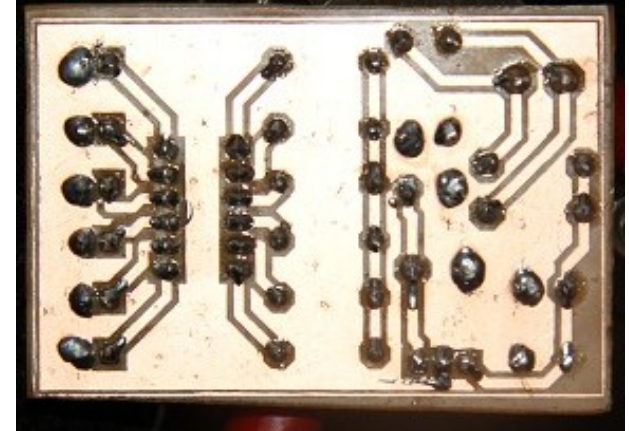
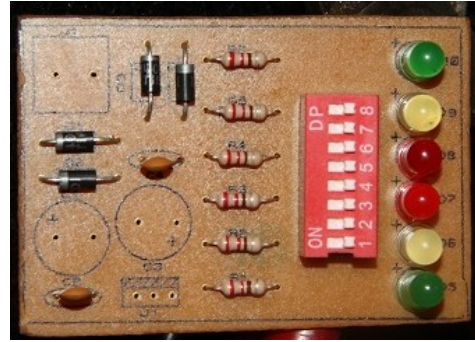
Apply Soldering Paste and Embed Resistors



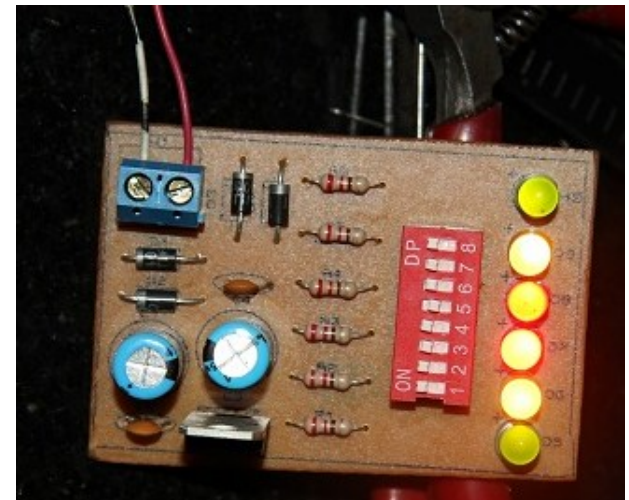
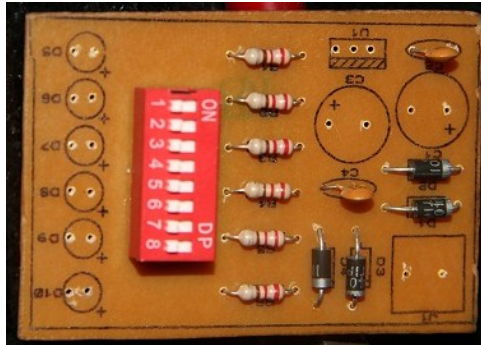
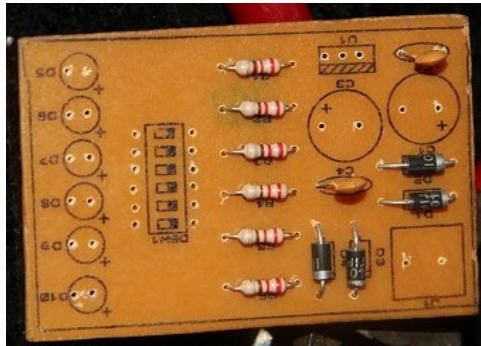
Solder Component Legs



Solder Components (Smaller to Bigger)

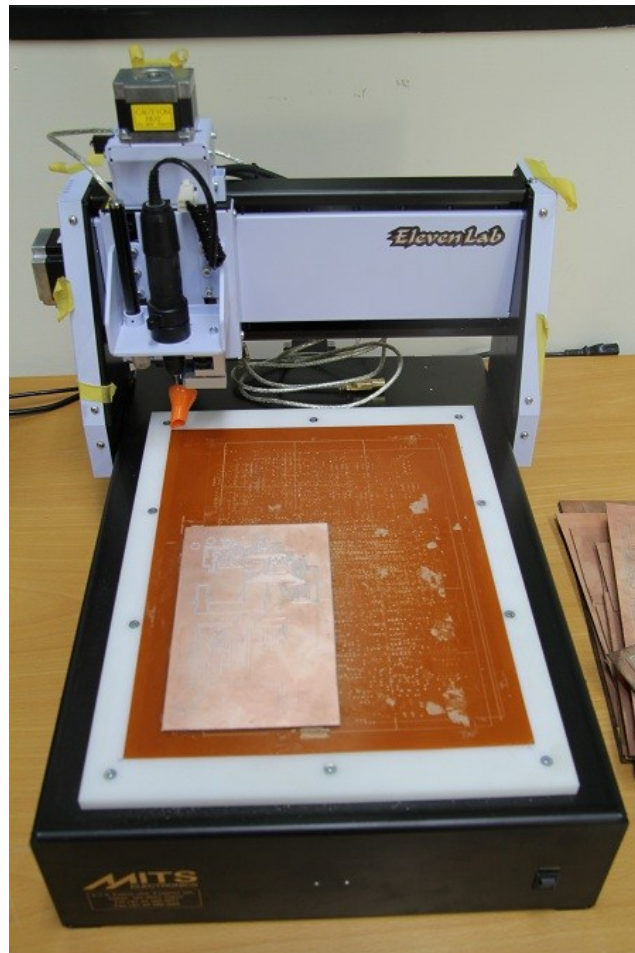


Testing (Power Up)



NON-CONVENTIONAL PCB PROTOTYPING

CNC Machine



Create CAD/CAM Files

The image shows a CAD software interface with a menu and a dialog box. The menu on the left has 'Gerber/Excellon Output...' highlighted with a red circle. The dialog box on the right is titled 'CAD/CAM (Gerber and Excellon) Output' and has several sections:

- 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:**

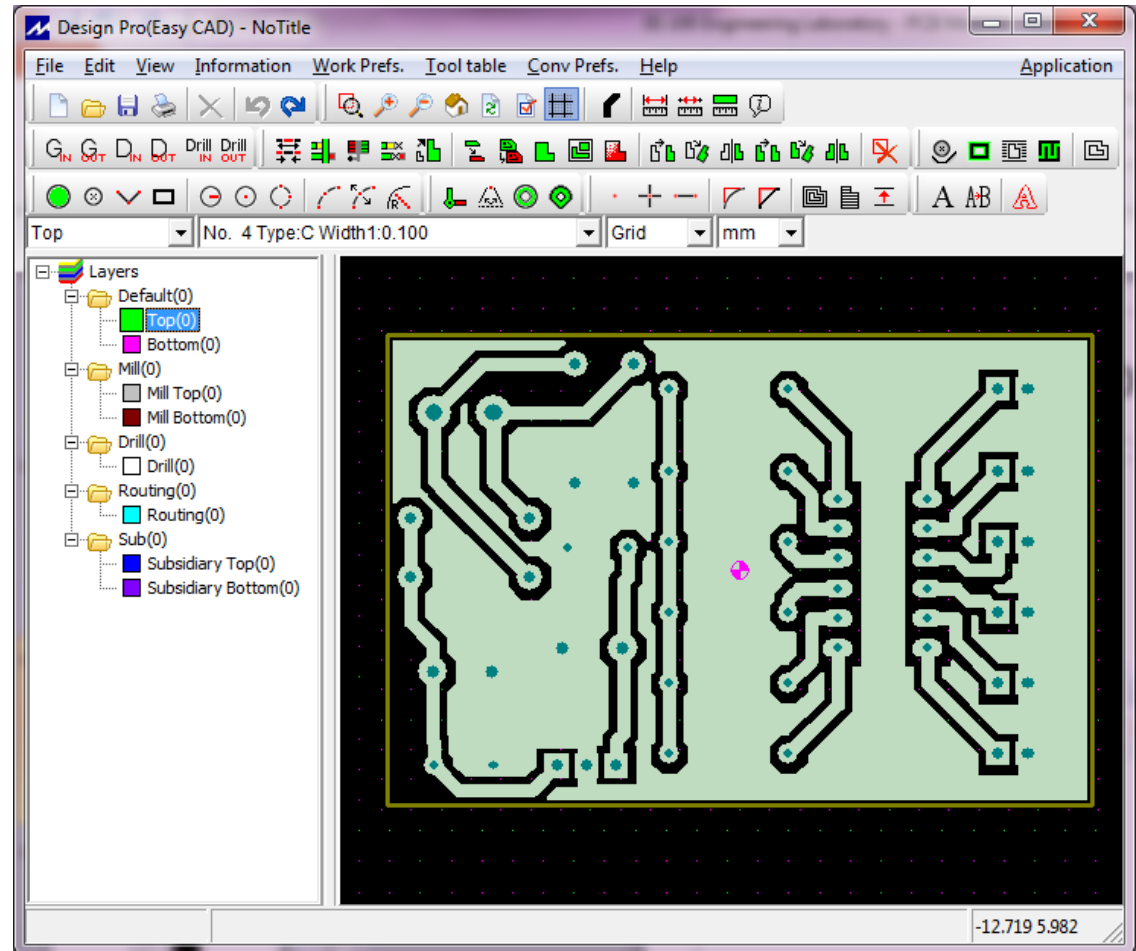
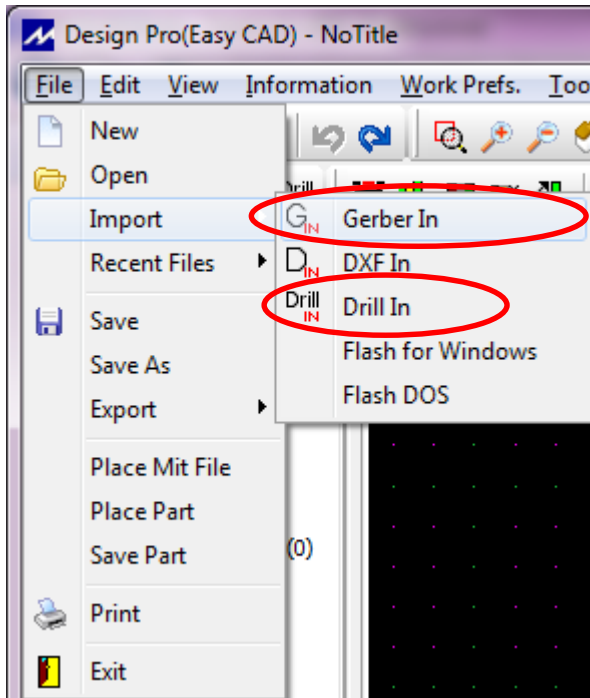
<input type="checkbox"/> Top Copper	<input type="checkbox"/> Inner 1	<input type="checkbox"/> Inner 8
<input checked="" type="checkbox"/> Bottom Copper	<input type="checkbox"/> Inner 2	<input type="checkbox"/> Inner 9
<input type="checkbox"/> Top Silk	<input type="checkbox"/> Inner 3	<input type="checkbox"/> 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

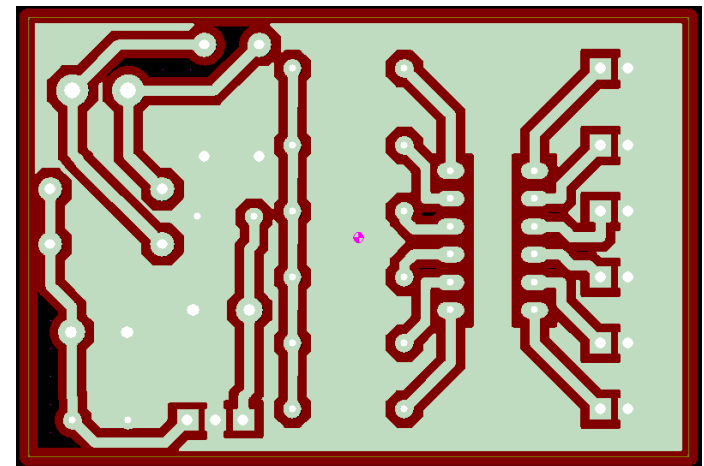
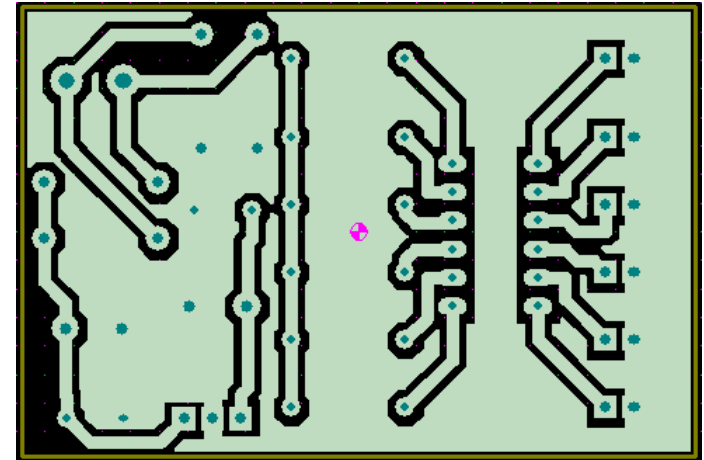
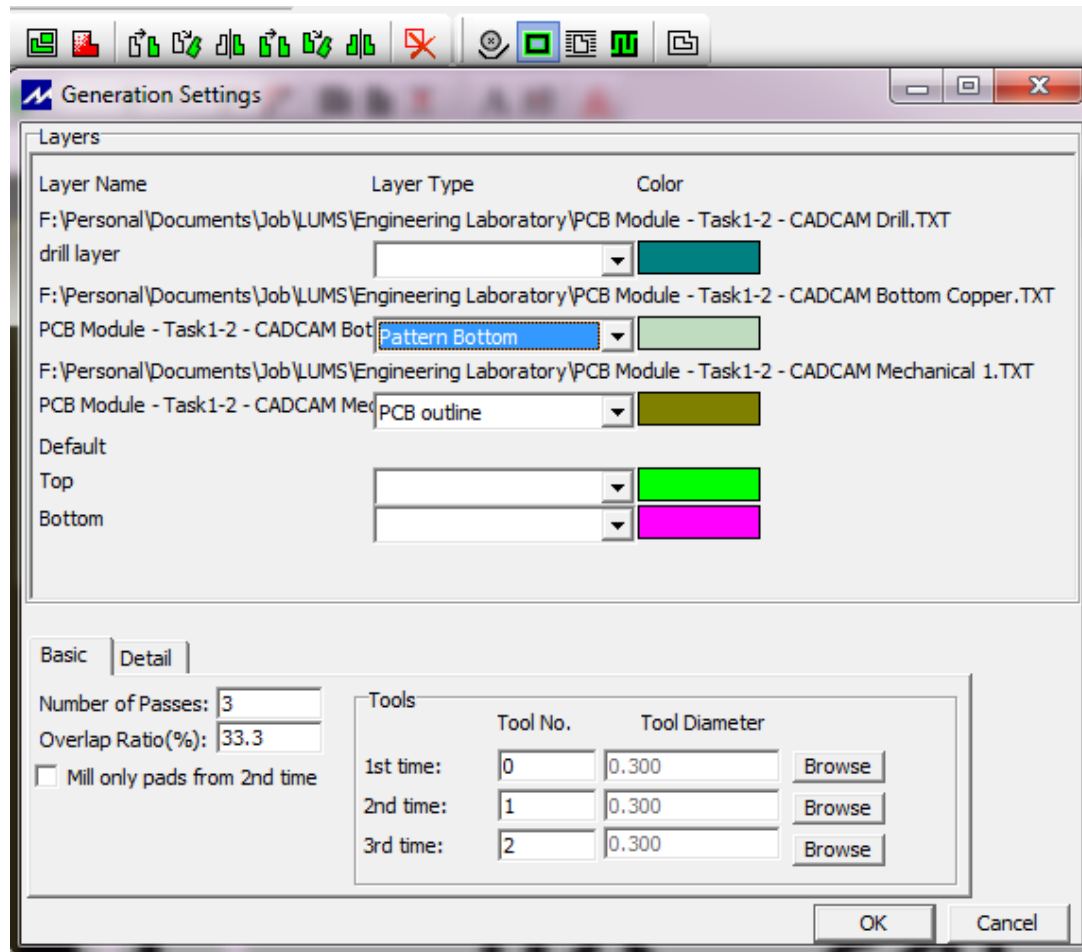
All None
- Rotation:**
 - X Horizontal
 - X Vertical
- Reflection:**
 - Normal
 - Mirror
- INF File Units:**
 - Imperial (thou)
 - Metric (mm)
 - Auto
- Gerber Format:**
 - RS274D
 - RS274X
- Slotting/Routing Layer:**
 - Mech 1
- Bitmap/Font Rasterizer:**
 - Resolution: 1000 dpi
- Run Gerber Viewer When Done?

OK Cancel

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



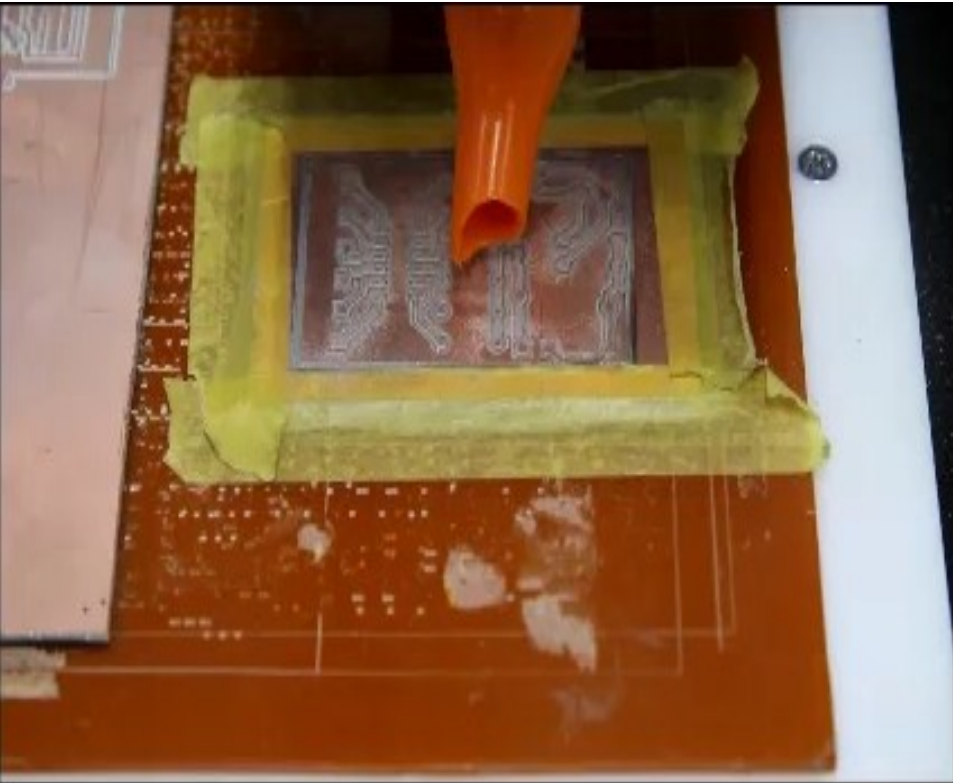
Create Drilling Marks and Milling Outlines



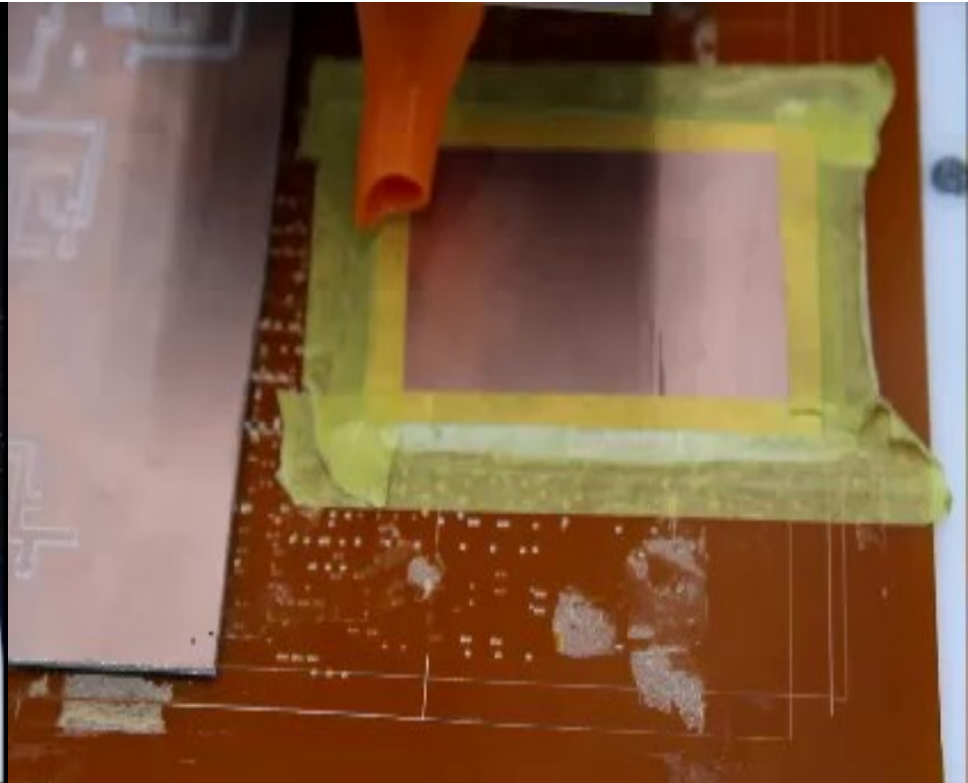
Final Output



Video Demonstration



PCB Drilling



PCB Milling

Lab Visit

- Conventional PCB Prototyping



- Non-Conventional PCB Prototyping

