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

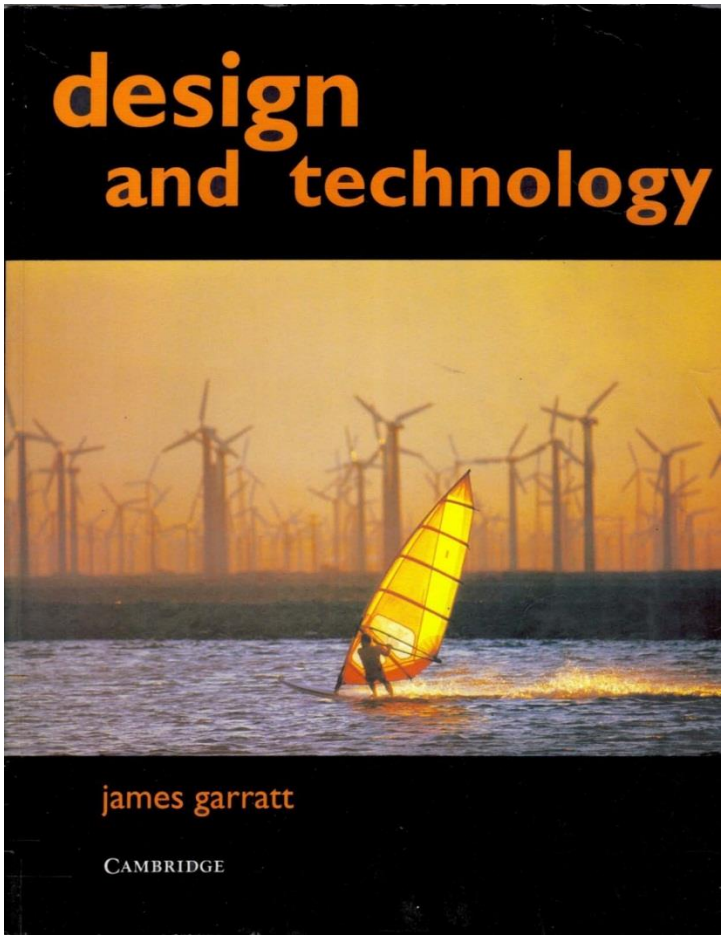
PCB Module

- 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

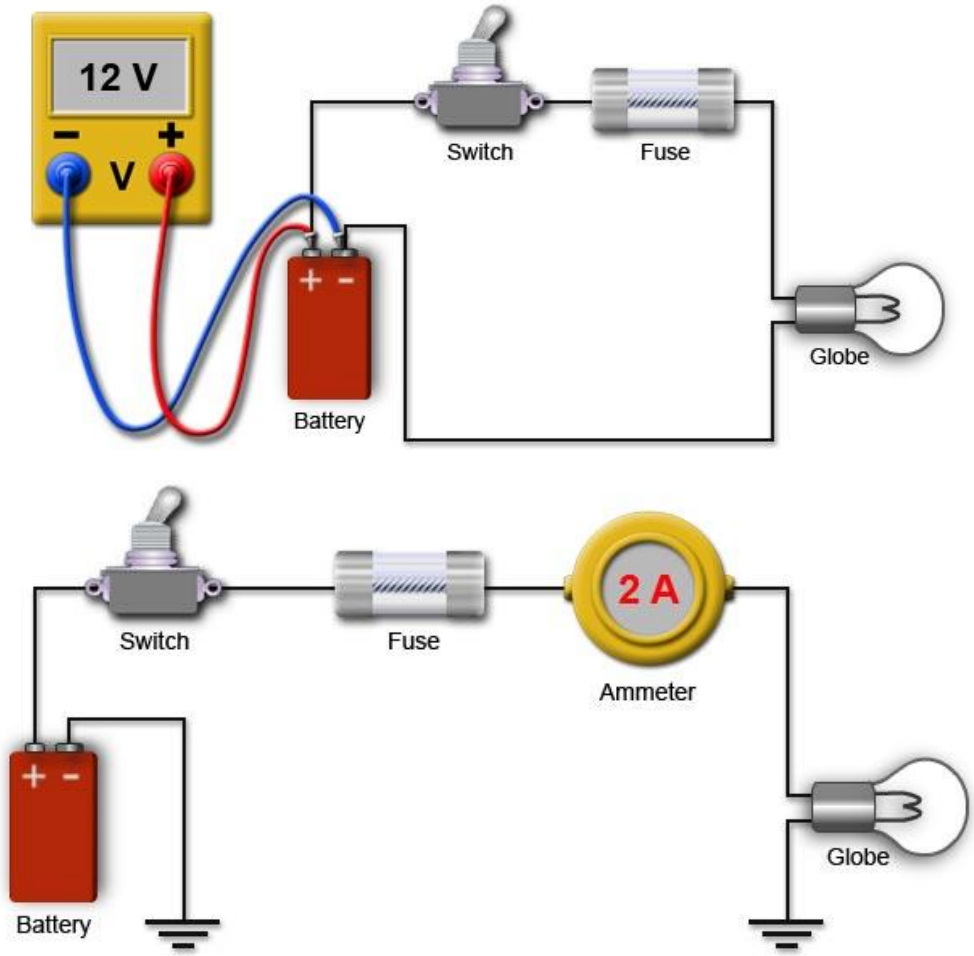
- Design and Technology
  - James Garratt
  - 2nd Edition
  - Cambridge Edition
- **Chapter 6**

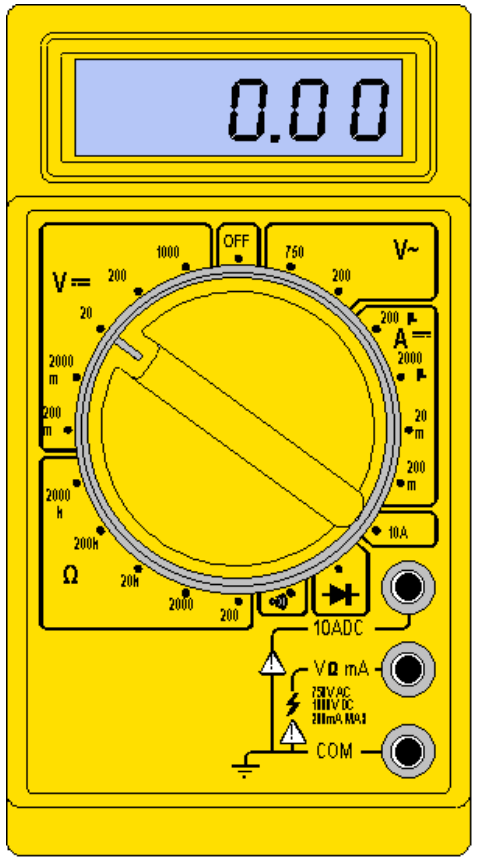
  Control electrics and electronics



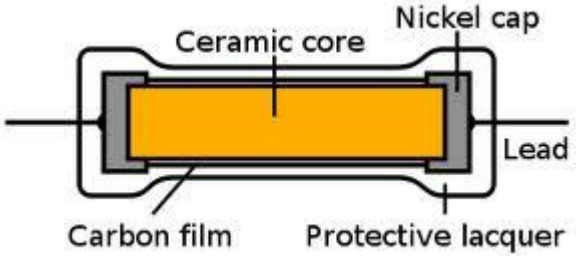
ELECTRONICS BASICS (REVIEW)

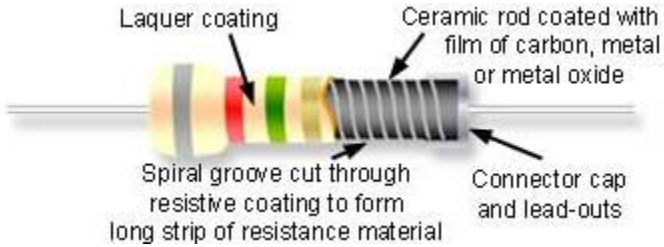
Voltage/Current Measurements



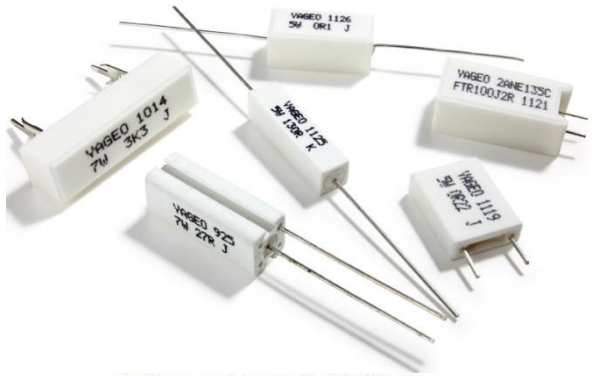


Resistor



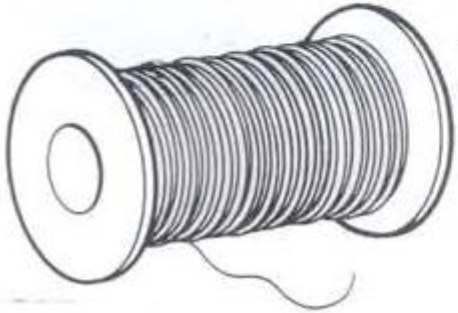


carbon resistor
(see colour code p.115)

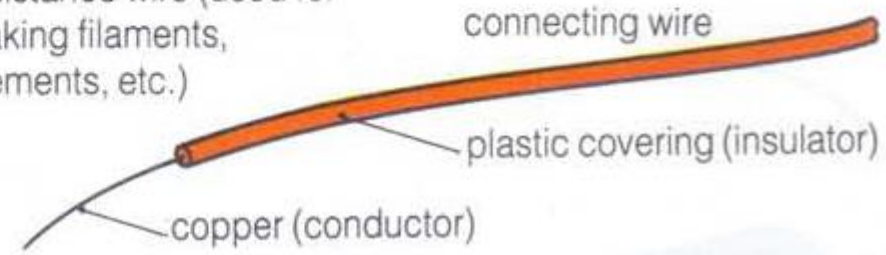


wire-wound resistor

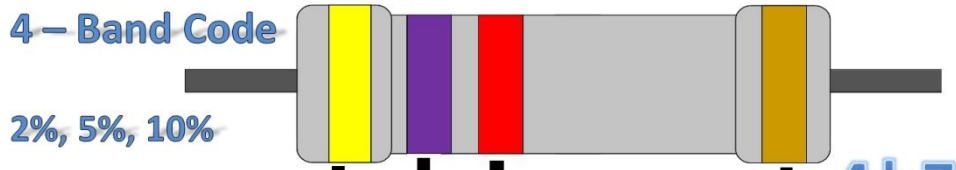
resistor symbol



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

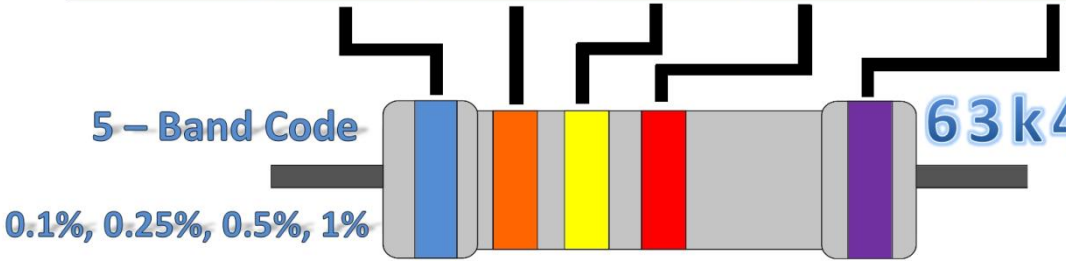


Resistor Color Code



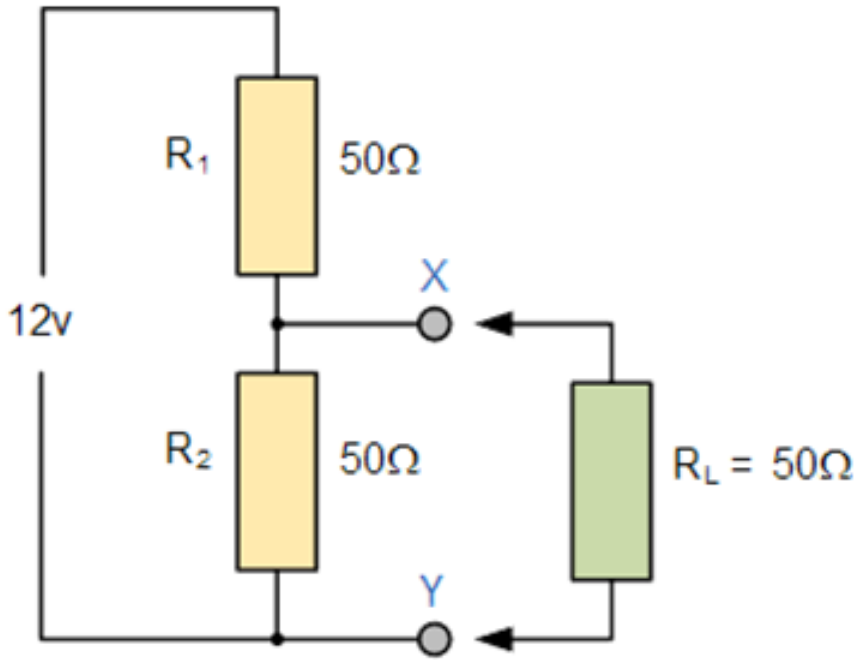
4k7Ω ±5%

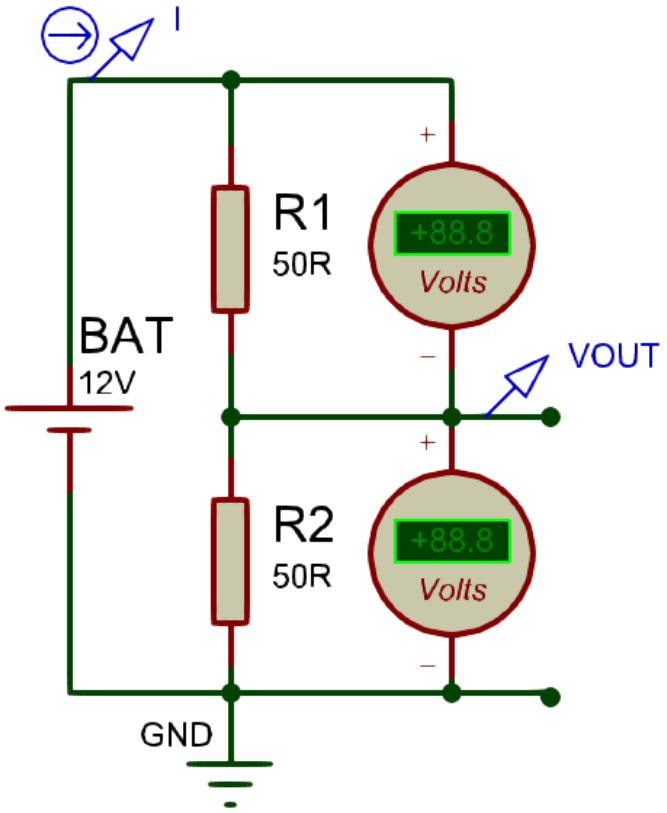
Color	1st Band	2nd Band	3rd Band	Multiplier	Tolerance
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1%
Red	2	2	2	100Ω	± 2%
Orange	3	3	3	1kΩ	
Yellow	4	4	4	10kΩ	
Green	5	5	5	100kΩ	± 0.5%
Blue	6	6	6	1MΩ	± 0.25%
Violet	7	7	7	10 MΩ	± 0.1%
Grey	8	8	8		± 0.05%
White	9	9	9		
Gold				0.1Ω	± 5%
Silver				0.01Ω	± 10%



63k4 0.1%

Voltage Divider





a) Without R_L connected

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

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

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

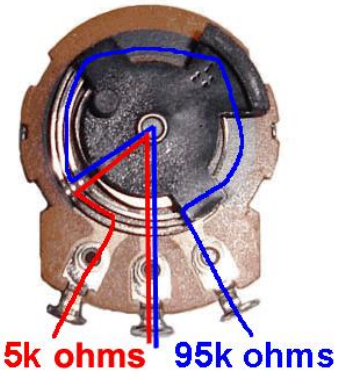
b) With R_L connected

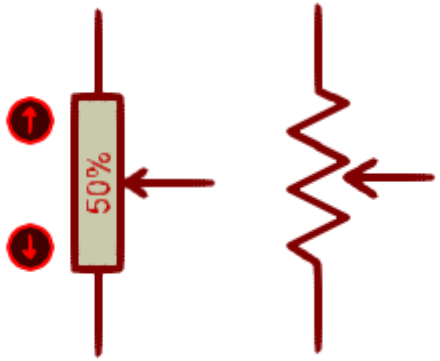
$R_{X-Y} = 25\Omega$ (Resistors in Parallel)

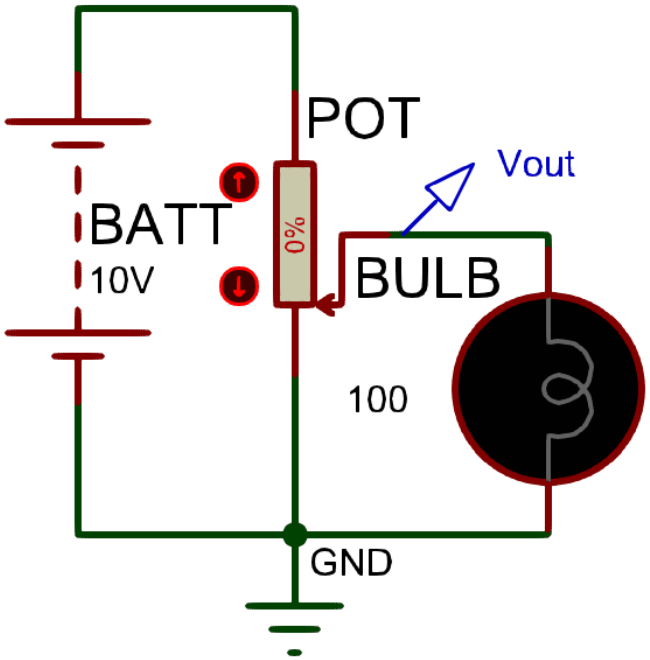
$$V_{out} = V_{in} \times \frac{R_2}{R_1 + R_2}$$

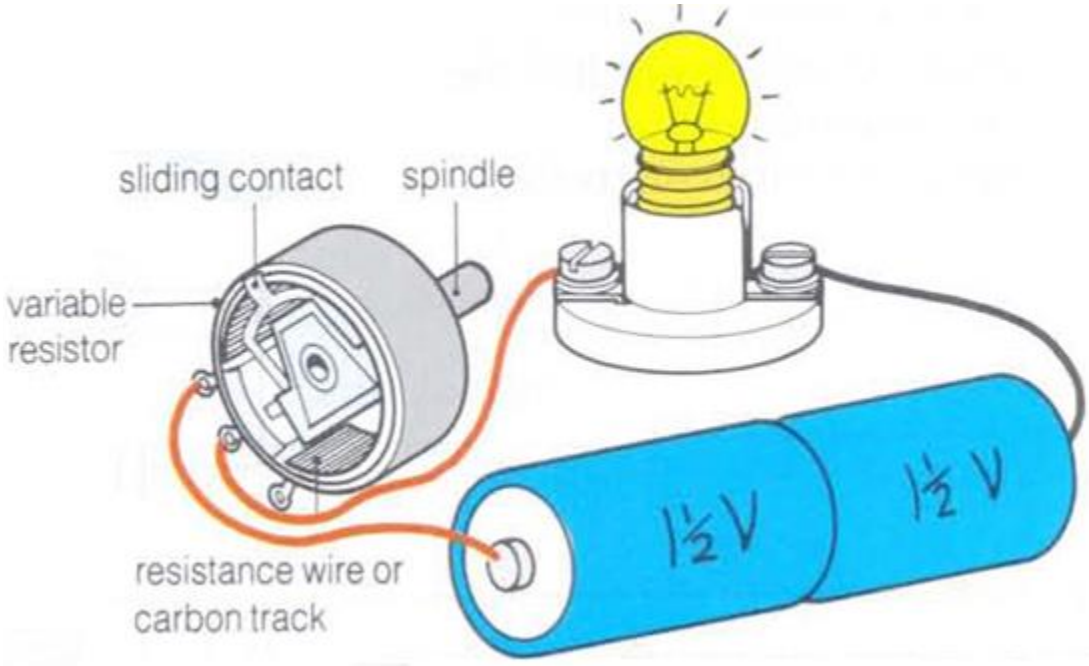
$$V_{out} = 12v \times \frac{25}{50 + 25} = 4.0v$$

Variable Resistor

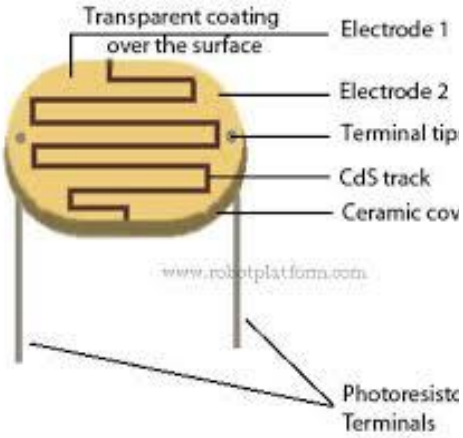


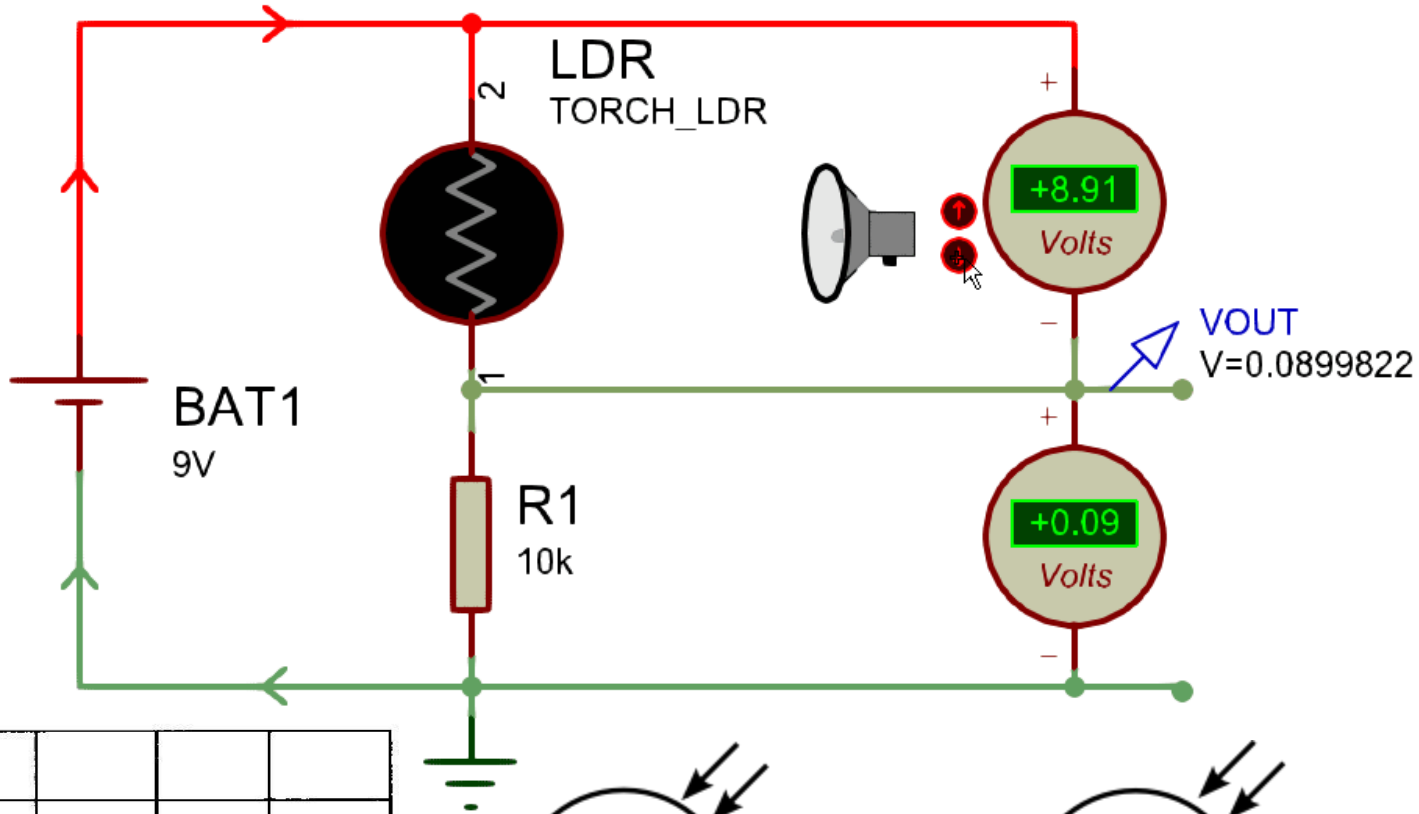


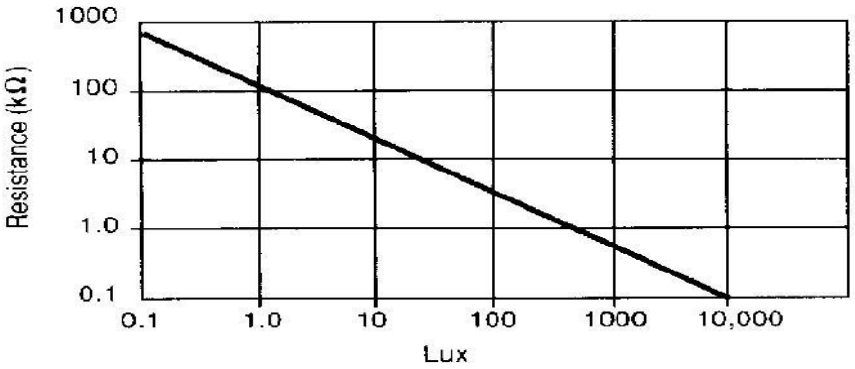


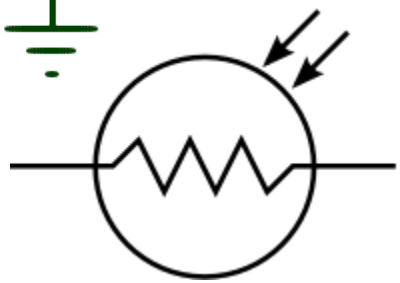


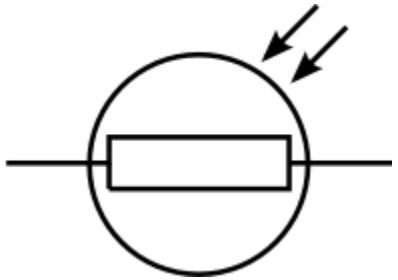
Light Dependent Resistor (LDR)







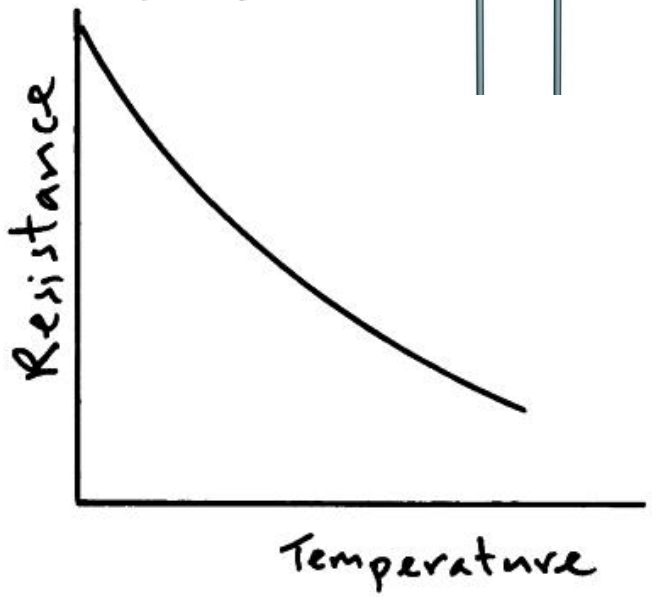


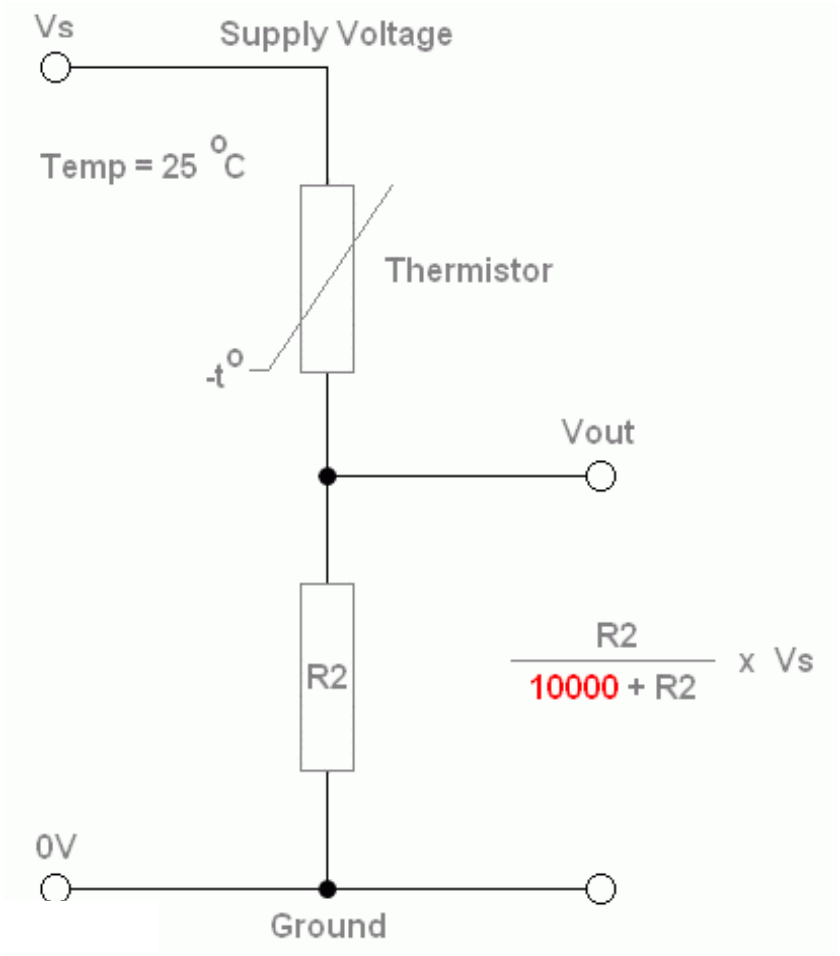


Thermistor


NTC
0.7D 20


PTC
C945
9940

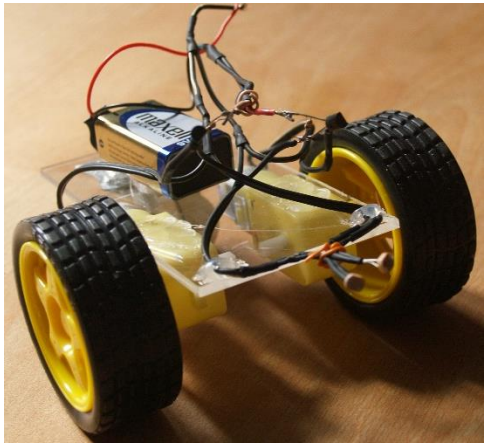

Resistance
Temperature

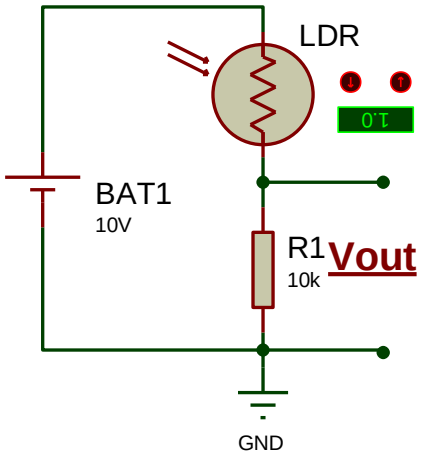

Vs
Supply Voltage
Temp = 25 °C
Thermistor
-t°
Vout
R2
R2
10000 + R2
x Vs
0V
Ground

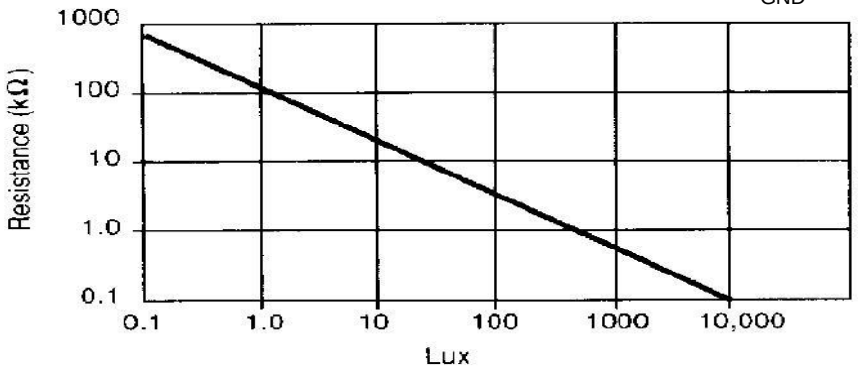
Lab Task 1(a)

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.

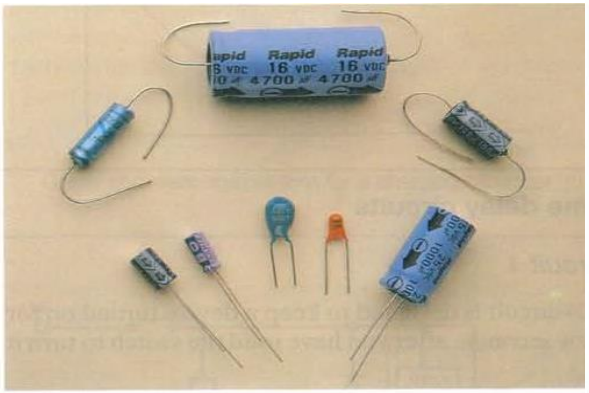
- Sketch the graph of V_{out} against intensity?
- Sketch the graph of V_{out} against intensity if the position of resistor R and LDR swapped?
- Redesign the value of the resistor such that $V_{out} = 1V$ at a light intensity of 1 Lux?



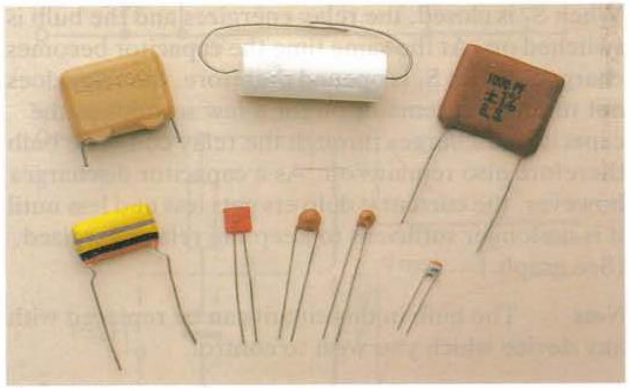


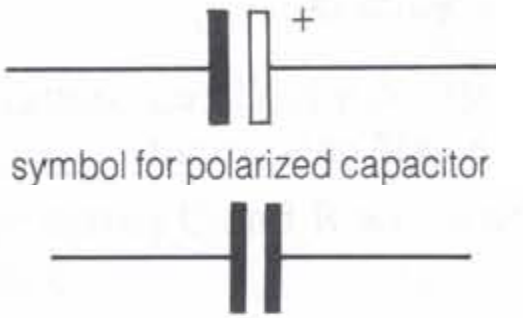


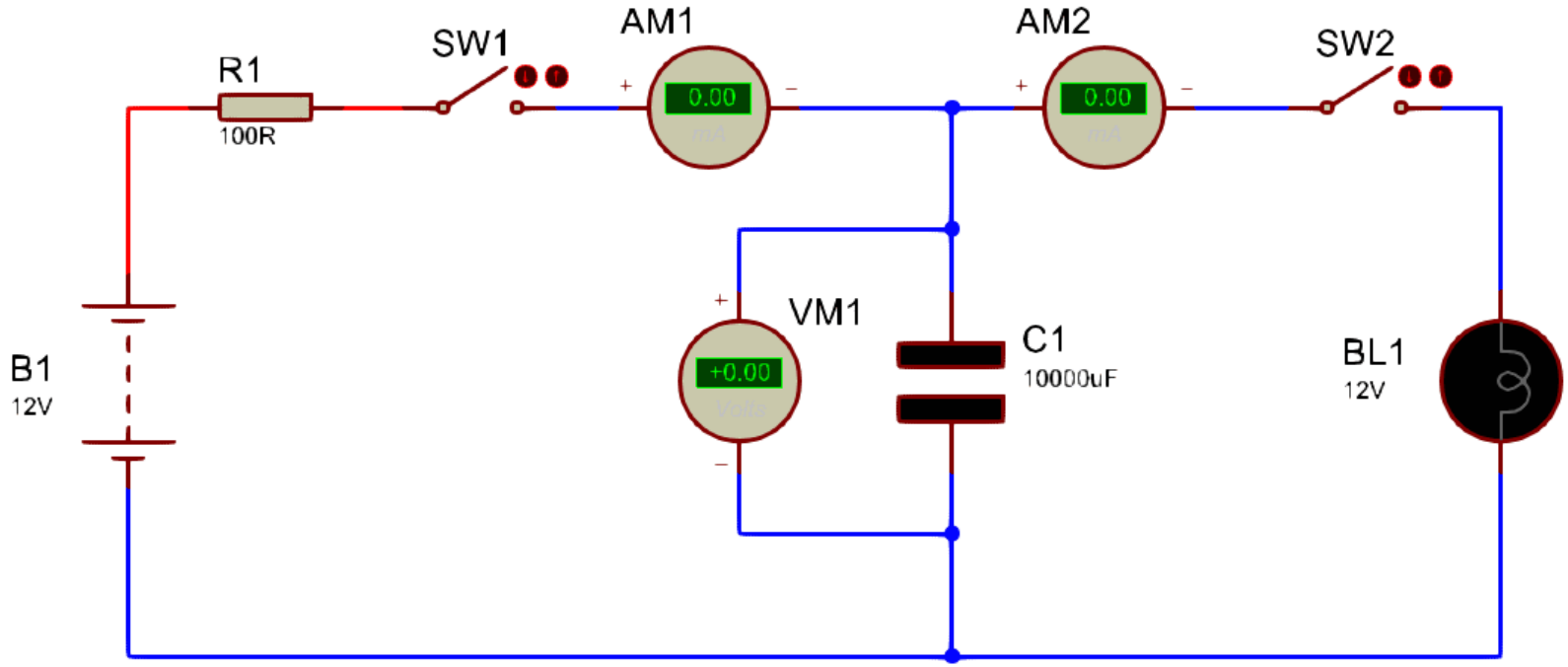
Capacitor



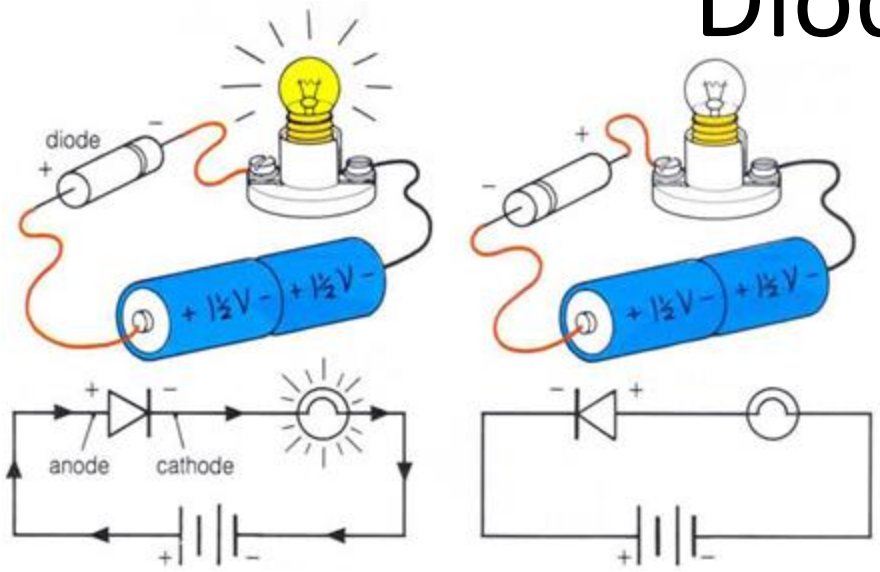
Polarized capacitors

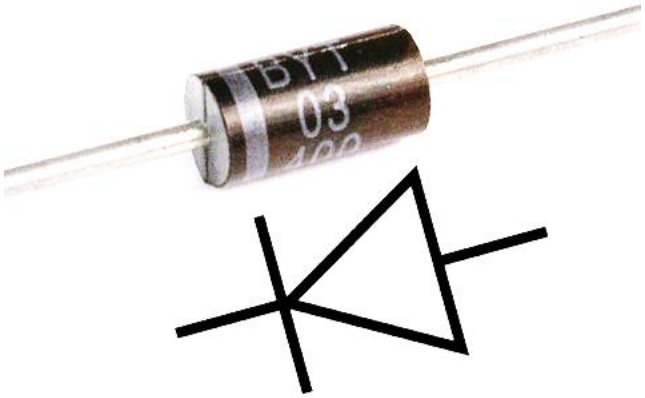

Non-polarized capacitors

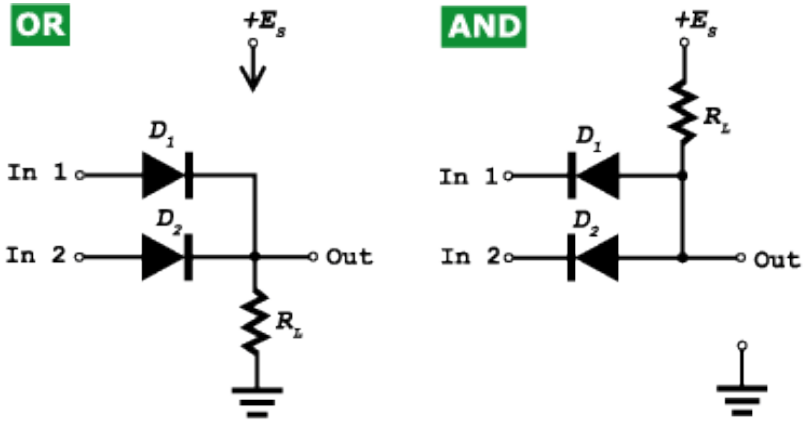




Diode







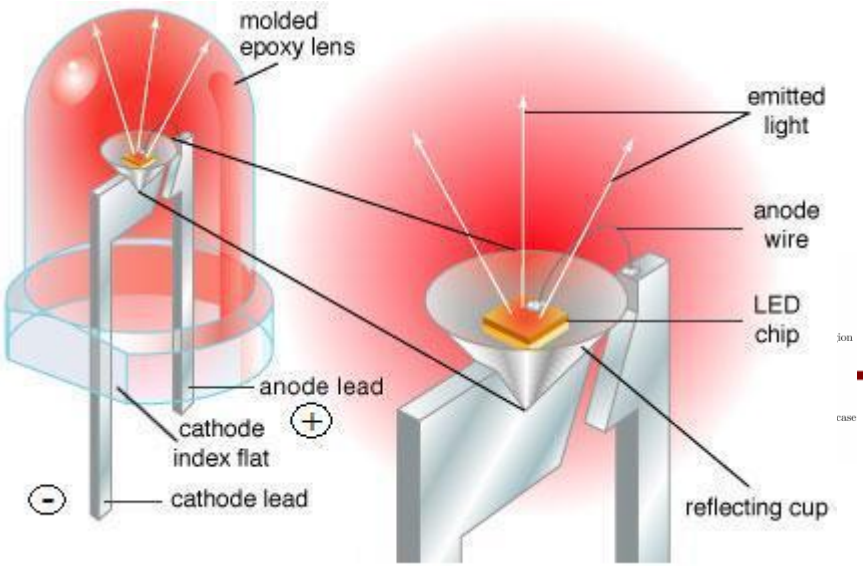
In 1	In 2	Out
0	0	0
0	1	1
1	0	1
1	1	1

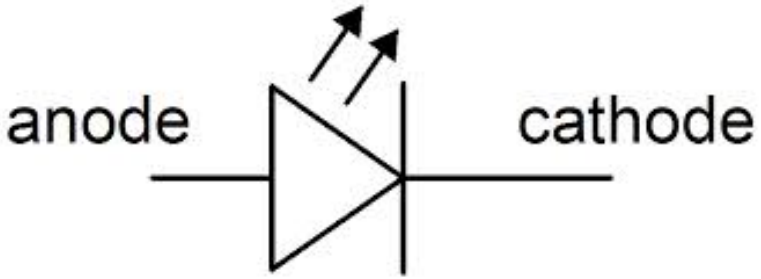
0 - 0V
1 - Es

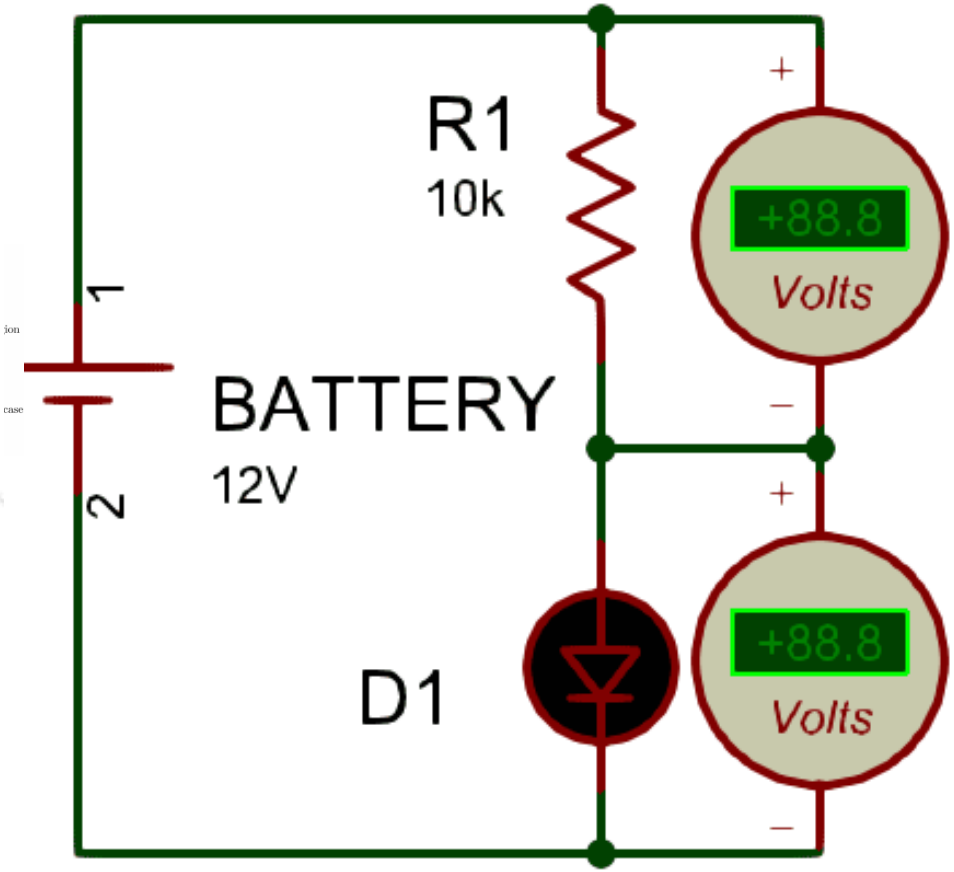
In 1	In 2	Out
0	0	0
0	1	0
1	0	0
1	1	1

Can we use a diode as voltage divider?

Light Emitting Diode (LED)

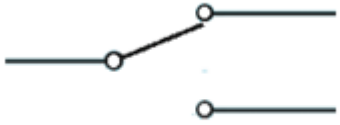




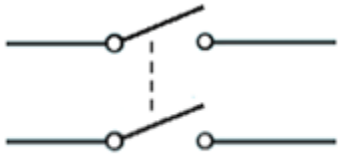


Switches

spst

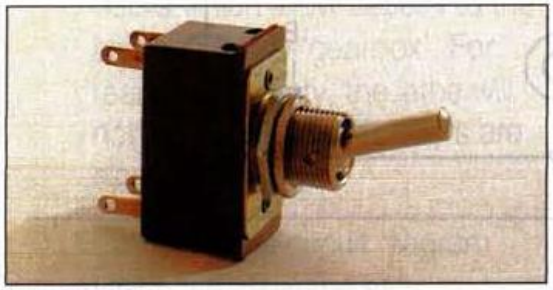


spdt

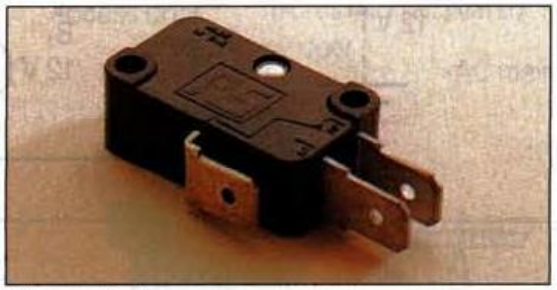


dpst

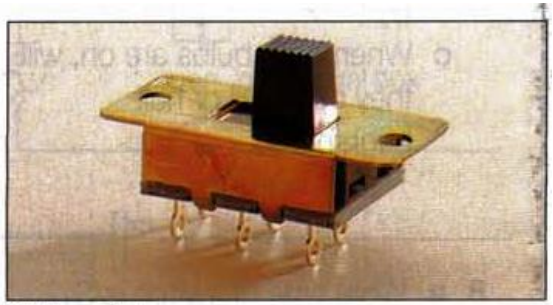
dpdt



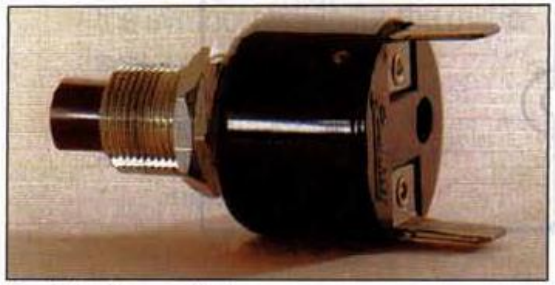
Toggle switch



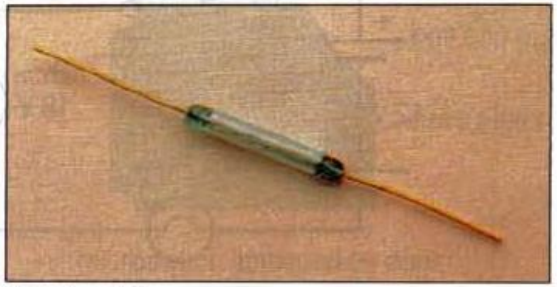
Microswitch



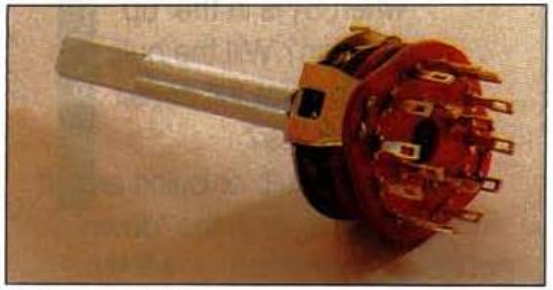
Slide switch



Push button switch

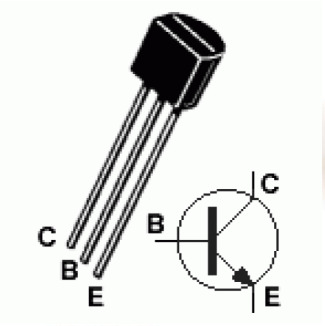


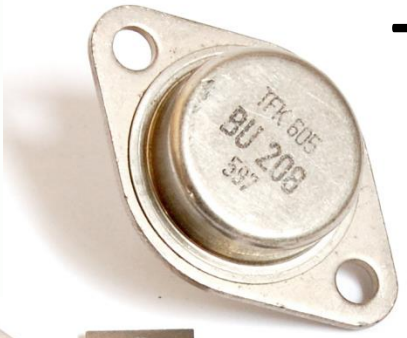
Reed switch

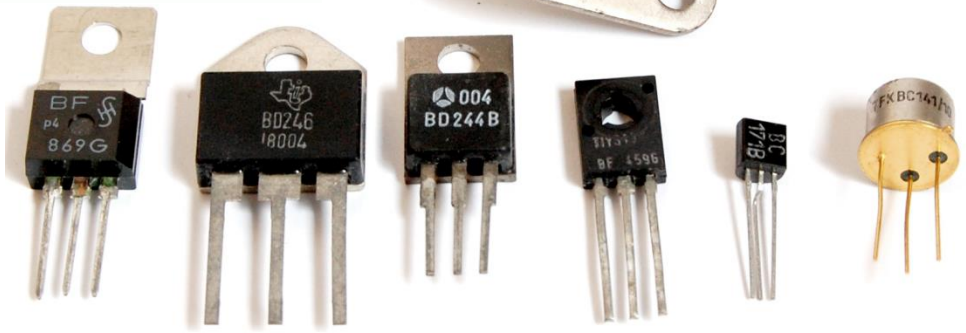


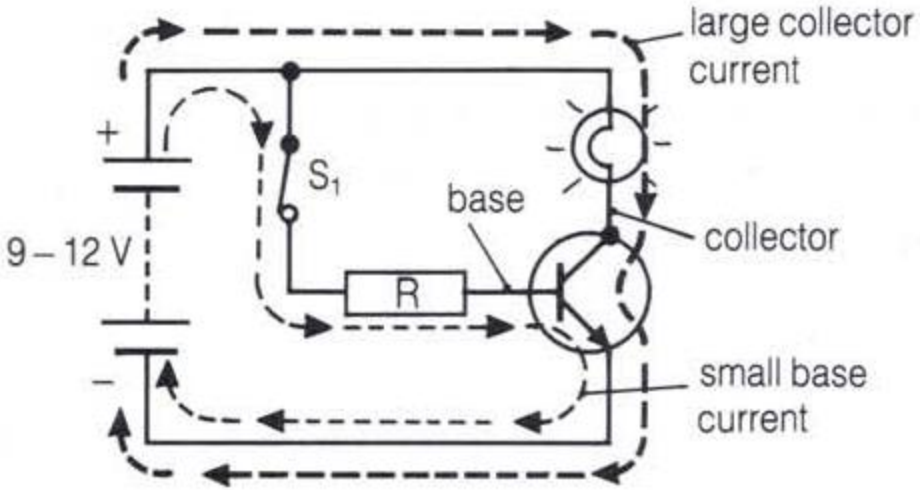
Rotary switch

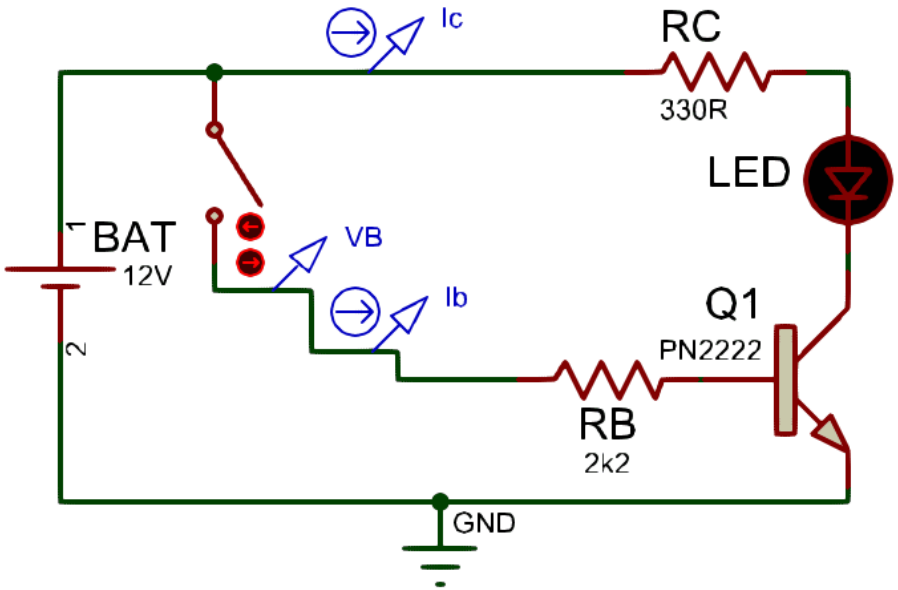
Transistor









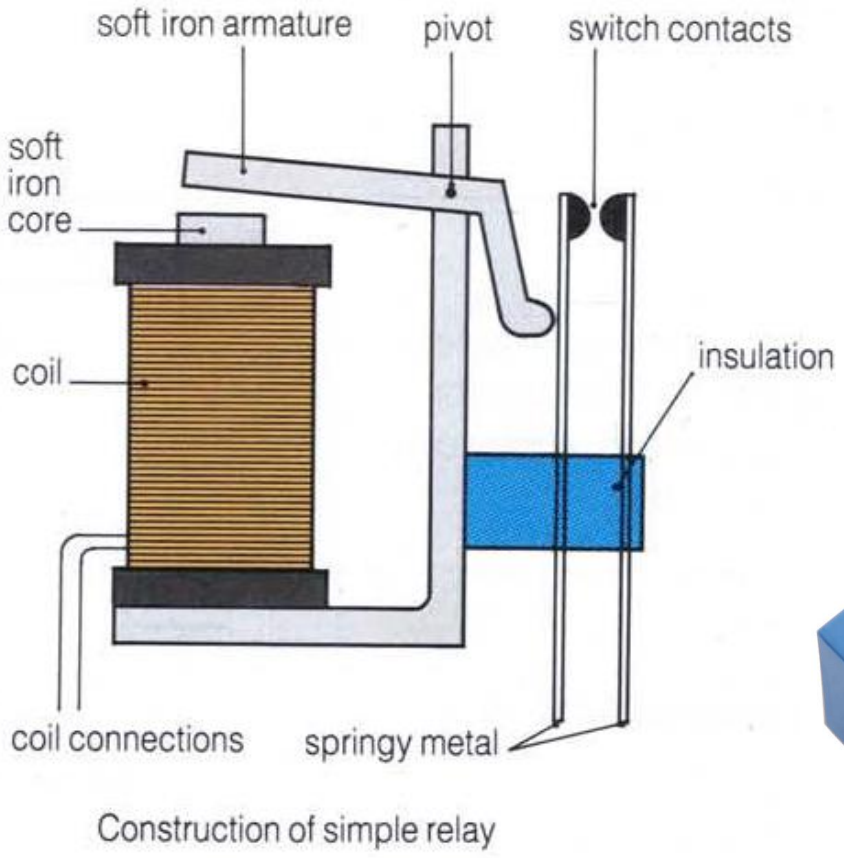


Base current flows, when the base is at-least 0.7V (Silicon) higher then emitter voltage.

How much is the amplification?

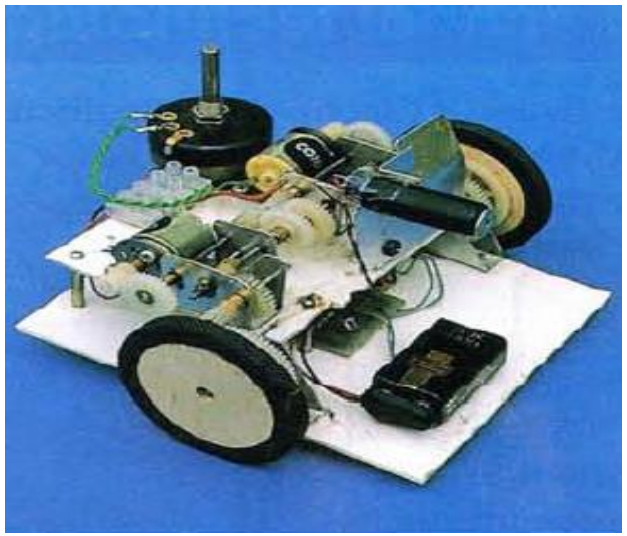
$$\beta = \frac{I_c}{I_b}$$

Relay

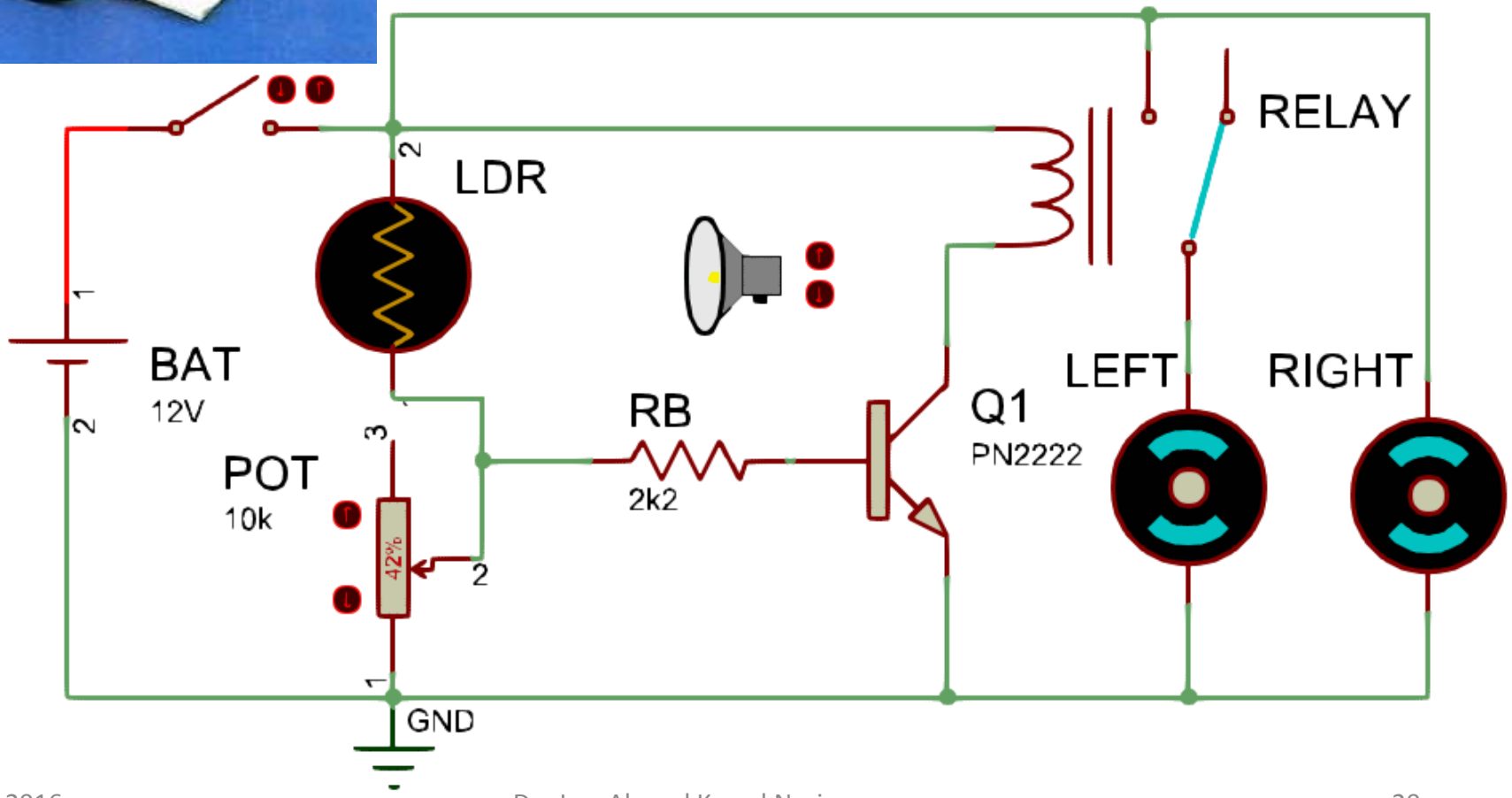


Construction of simple relay

What is the advantage of a relay over a transistor?



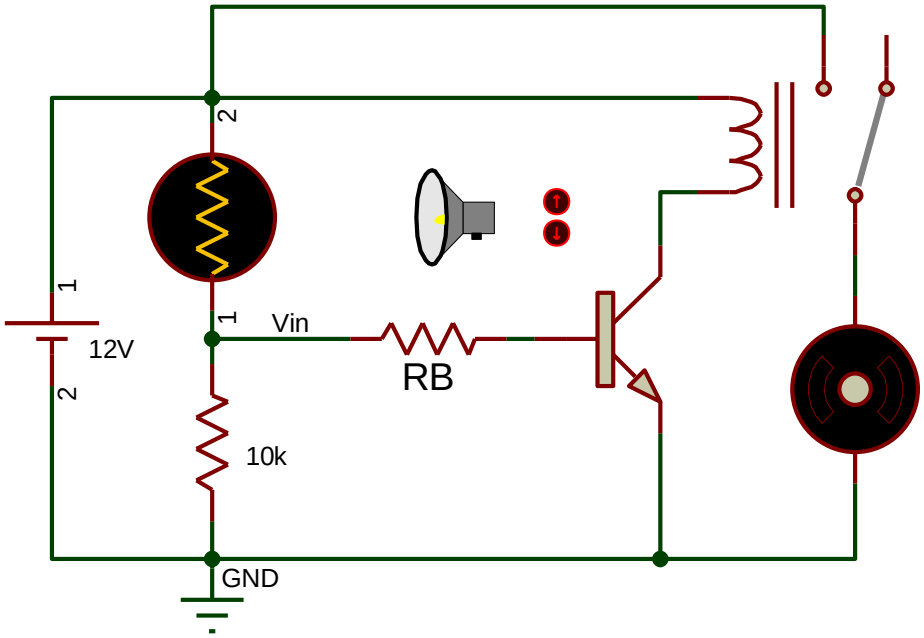
Relay Application



Lab Task 1(b)

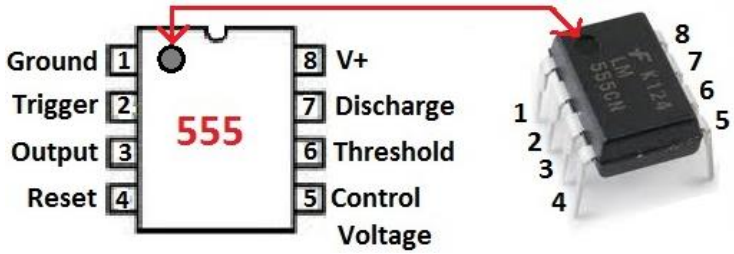
The relay in the circuit turns on when $50mA$ of current flows through its coil. The transistor used in the circuit has $\beta = 100$ and $V_b = 0.7V$

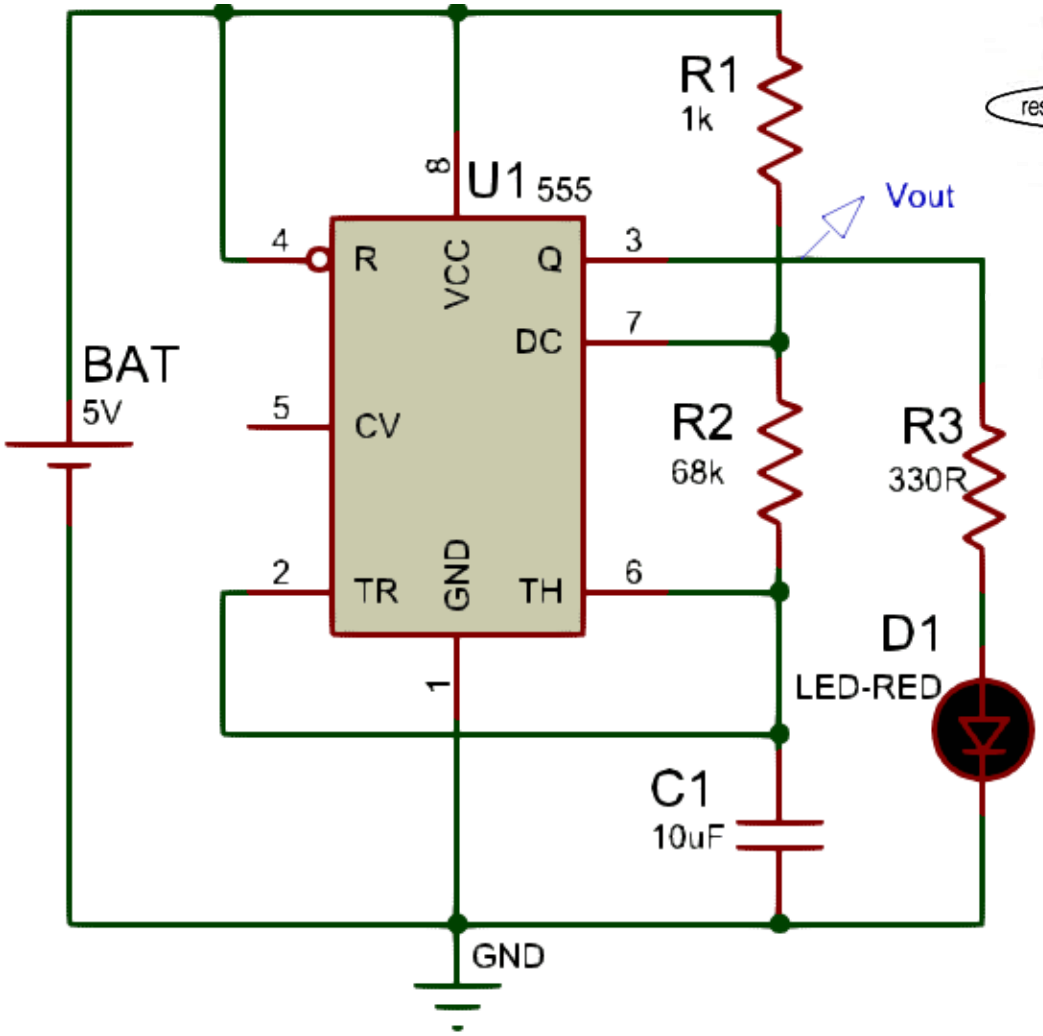
- How much base current is required to turn on the transistor?
- At which voltage (Vin) the motor will turned on, considering $\mathrm{RB} = 2\mathrm{k}2$?



Reference: Design and Technology, Page #149

Timer 555





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

resistance in ohms

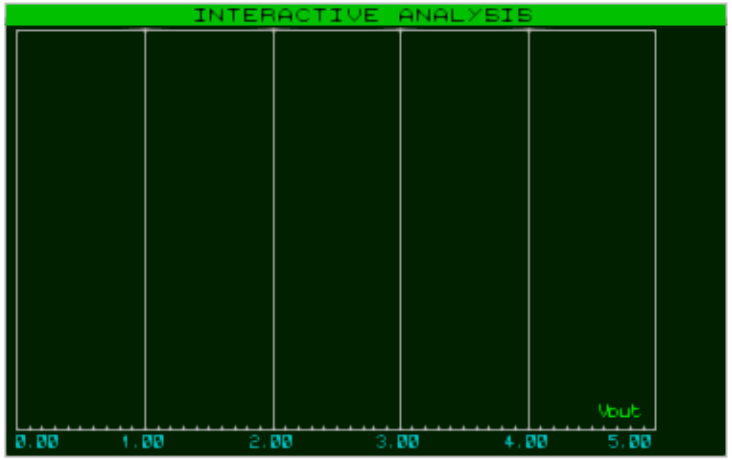
capacitance in farads

For above example:

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

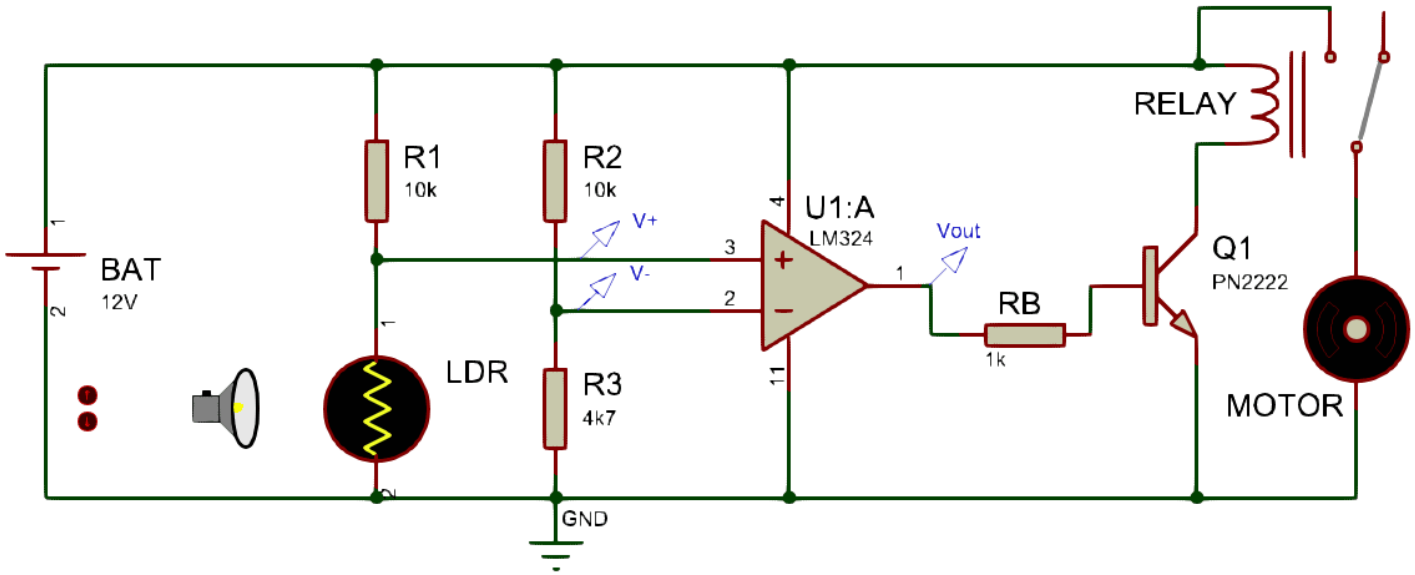
$$f = \frac{1.44}{1.37}$$

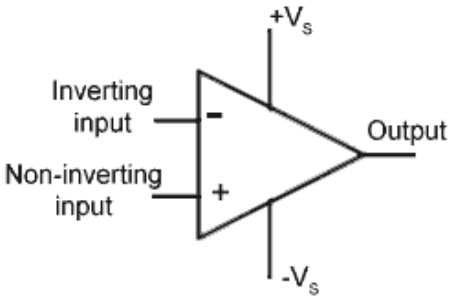
$$f = 1.05 \text{ Hz}$$

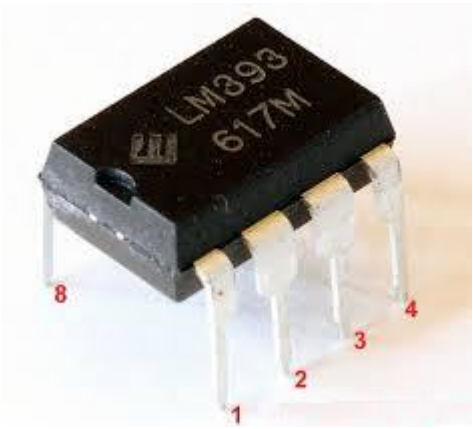


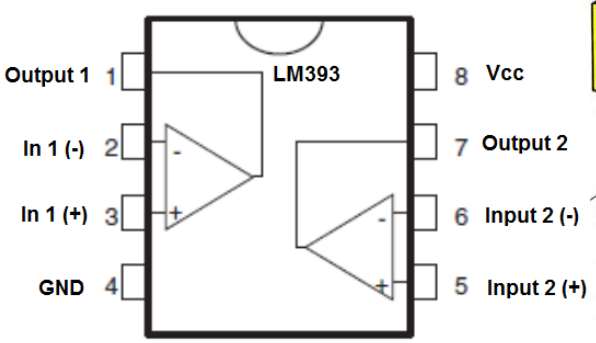
Reference: Design and Technology, Page #140

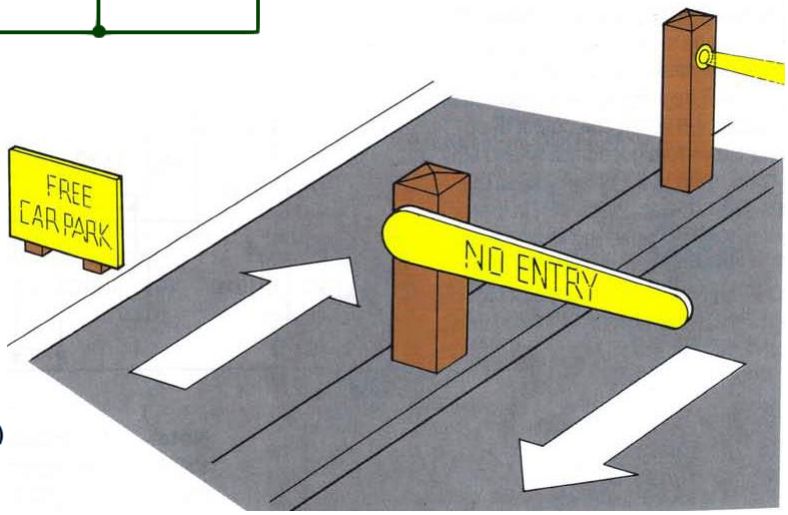
Operational Amplifier (Op-Amp)



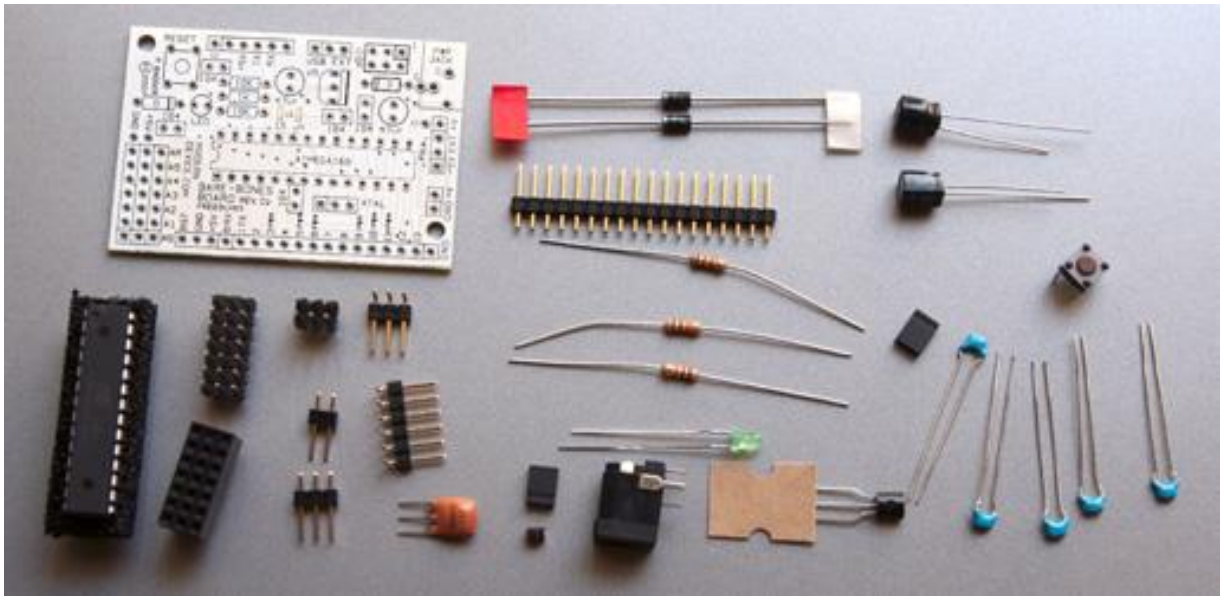


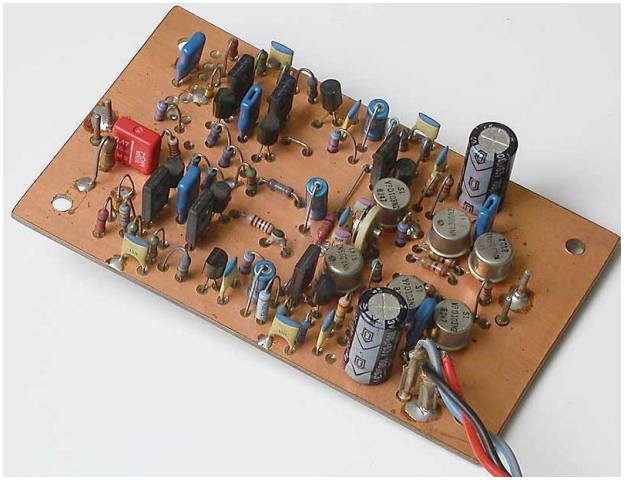


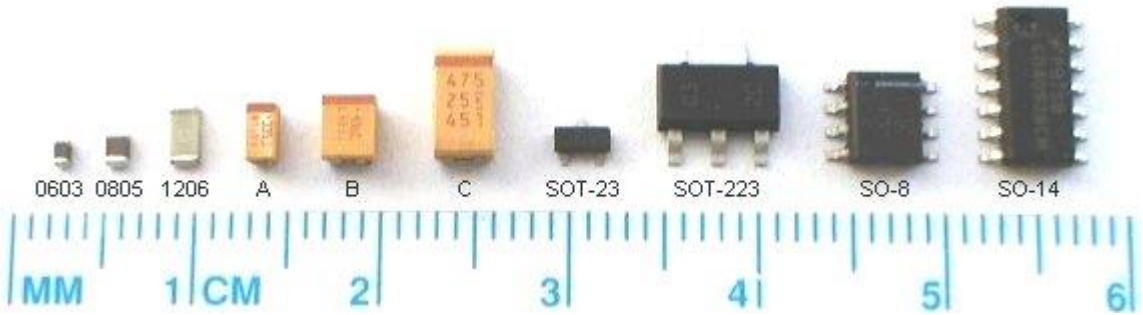


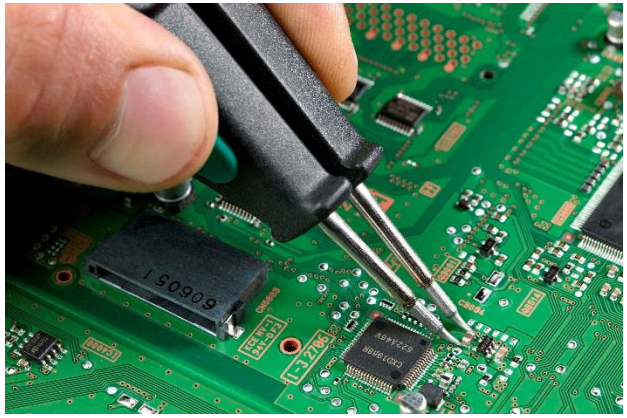


Through-Hole/SMD Components





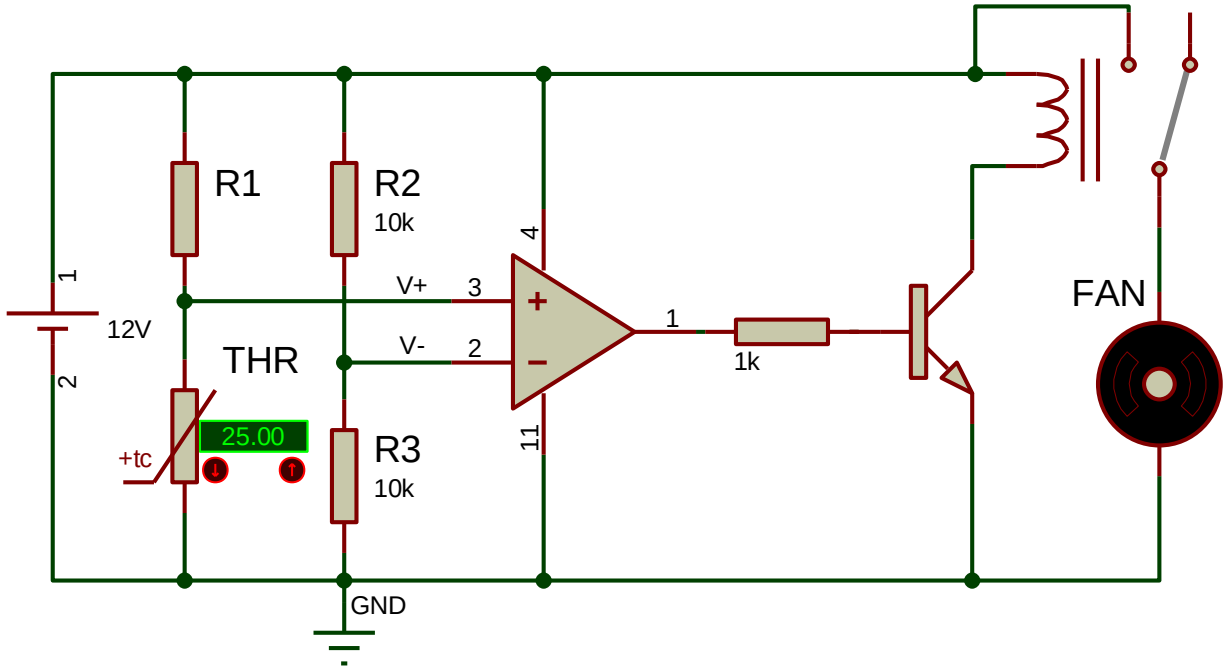




Lab Task 1(c)

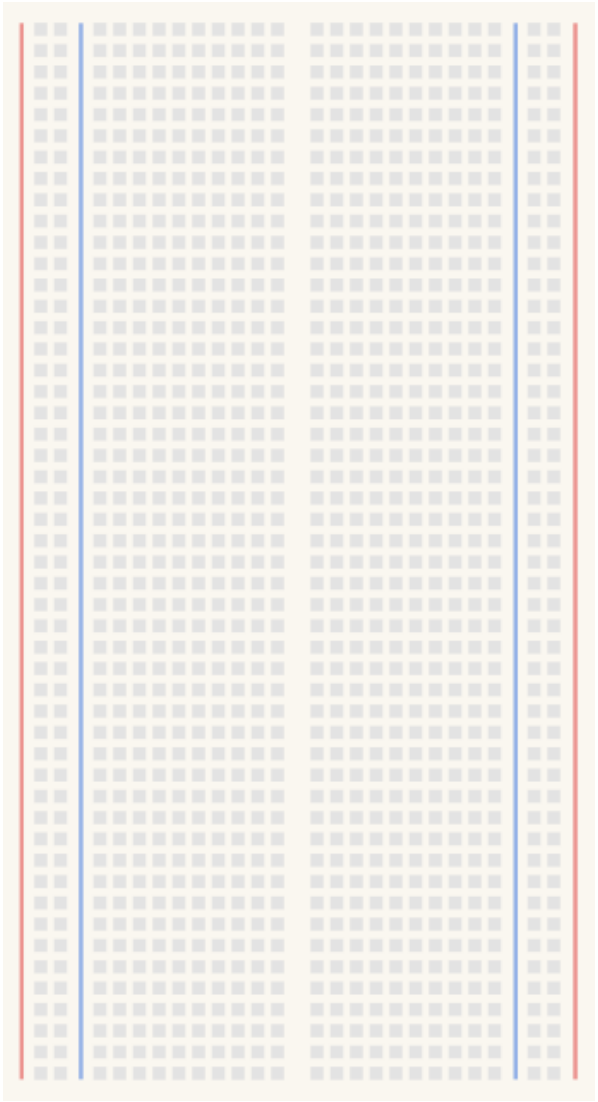
The following circuit uses thermistor and an op-amp to control the temperature of a room. The fan is required to maintain the room temperature at $25°C$.

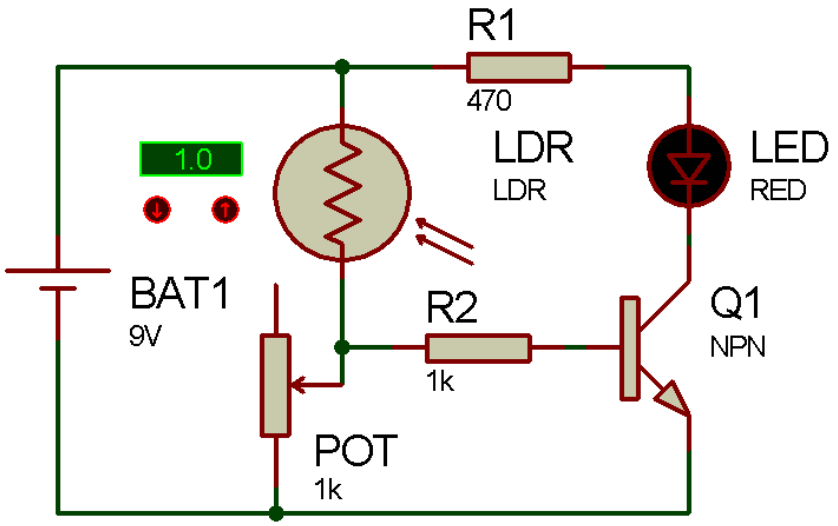
- At what voltage $(V+)$ the fan turns on?
- What is the value of resistance R1 required to **just** turn on the fan. The resistance of thermistor (RT1) is $10K\Omega$ at the temperature of $25°C$?

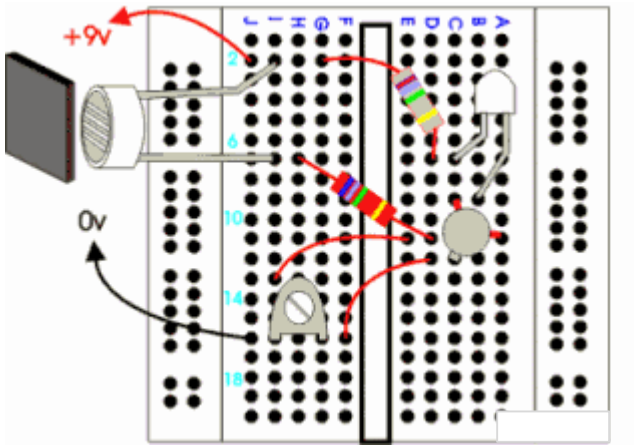


PCB PROTOTYPING CONVENTIONAL

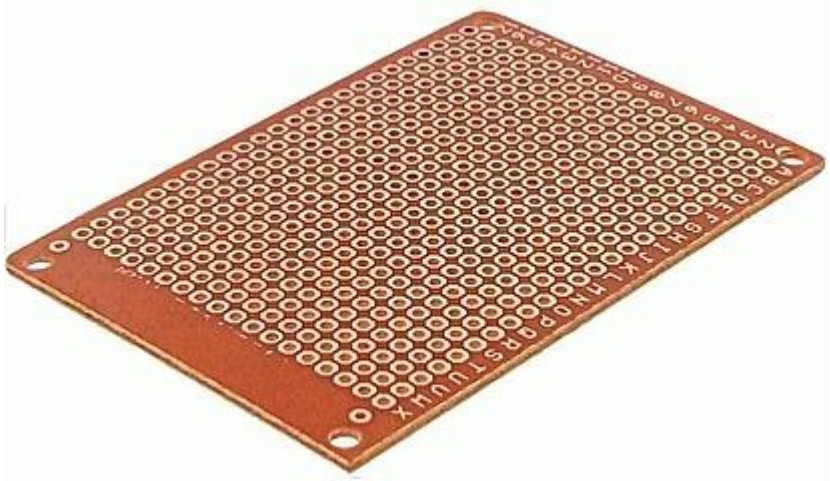
Bread Board

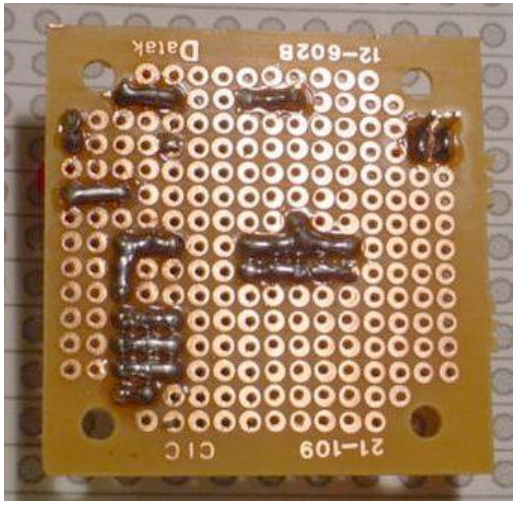


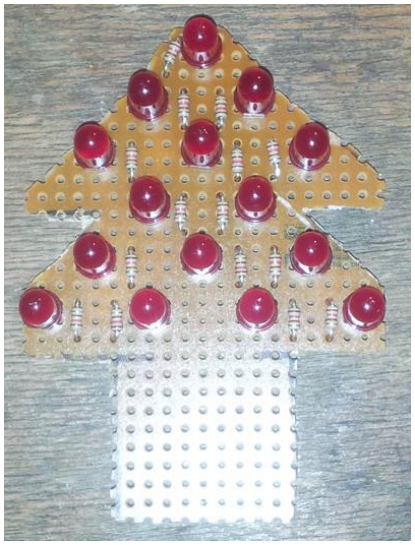


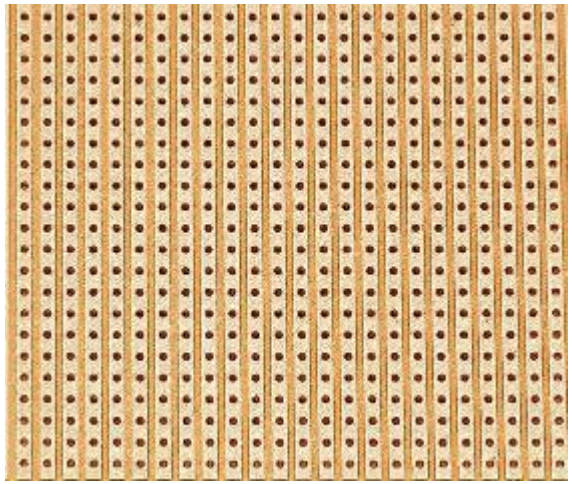


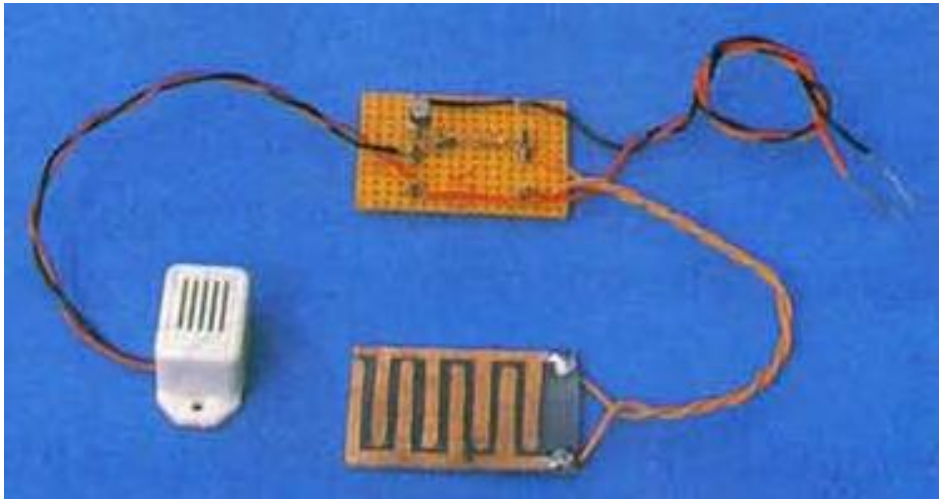
Vero Board (Matrix/Strip)



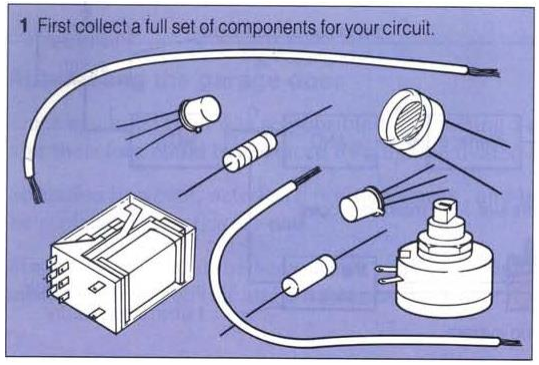


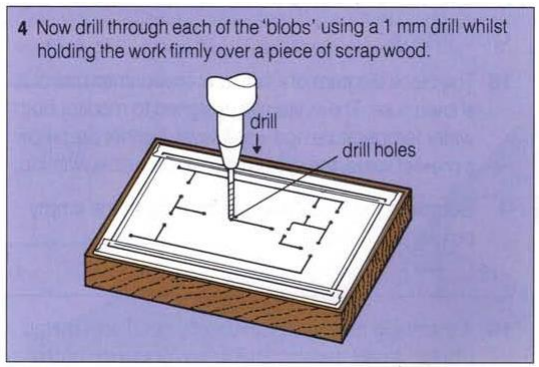


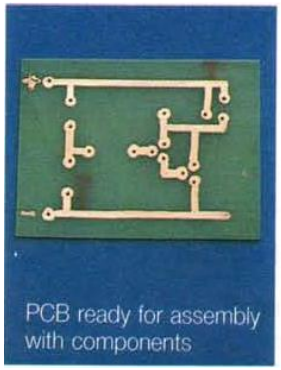


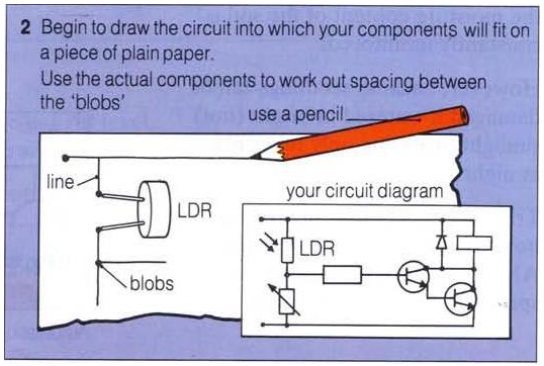


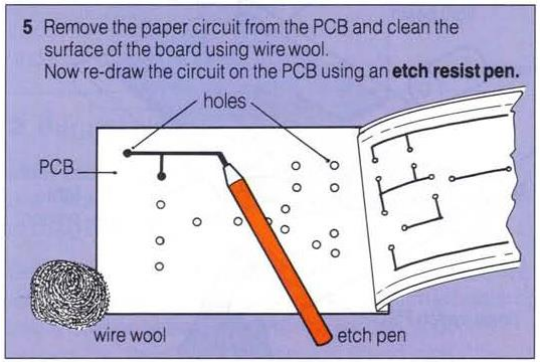
Single Layer PCB Prototyping Workflow

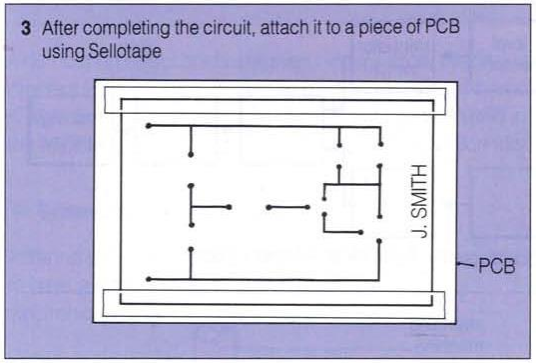


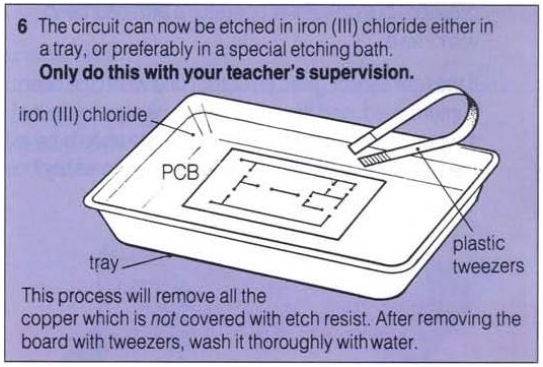


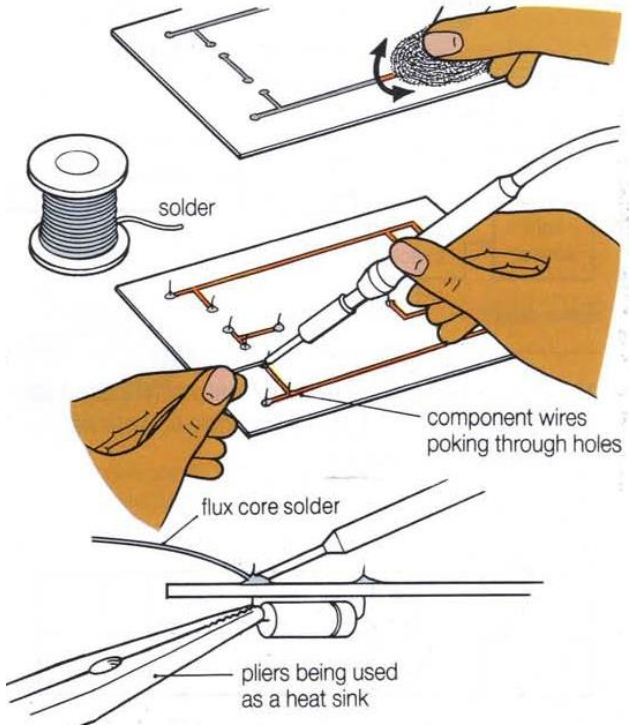




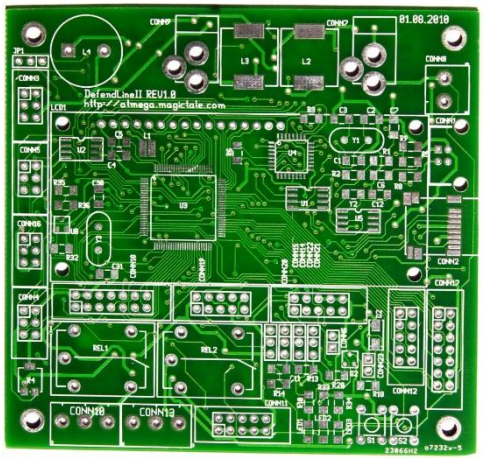


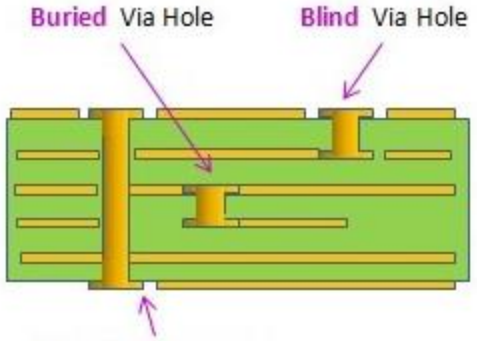


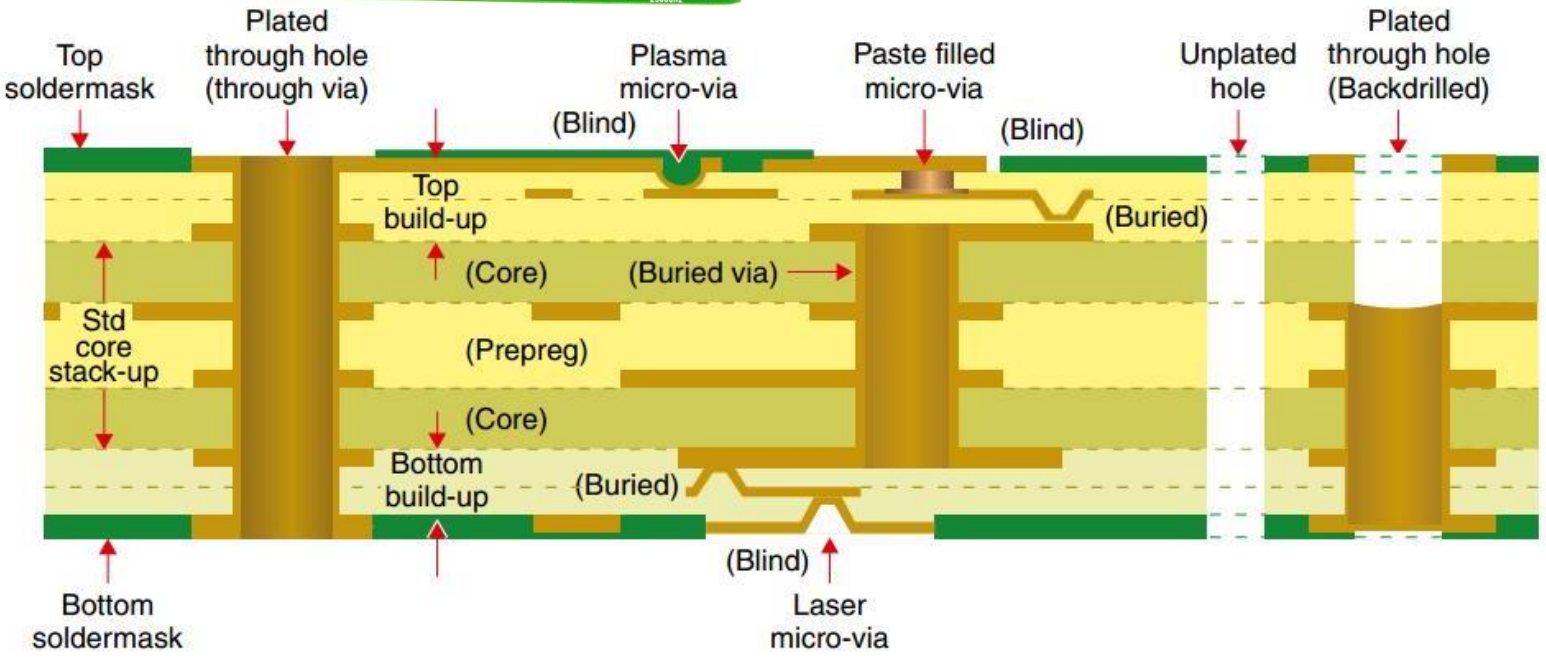




PCB Nomenclature

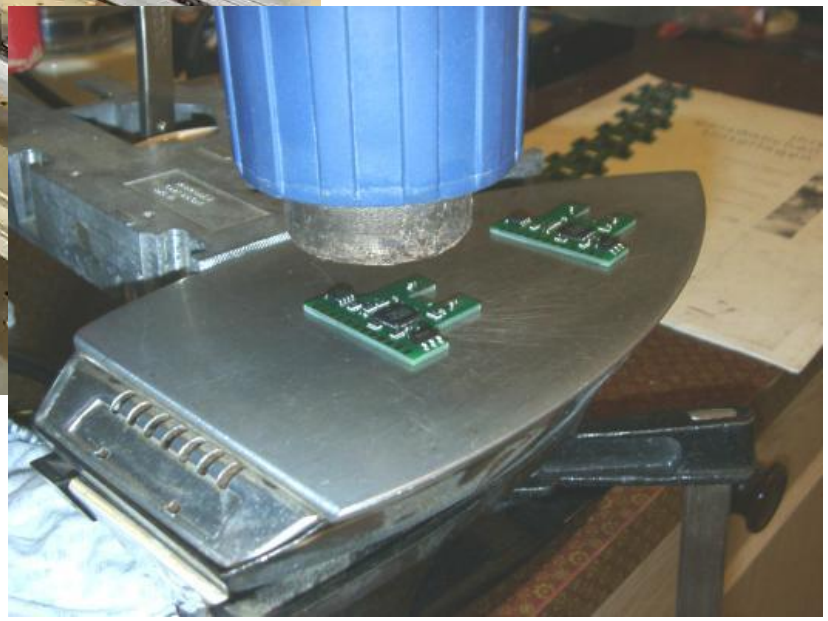






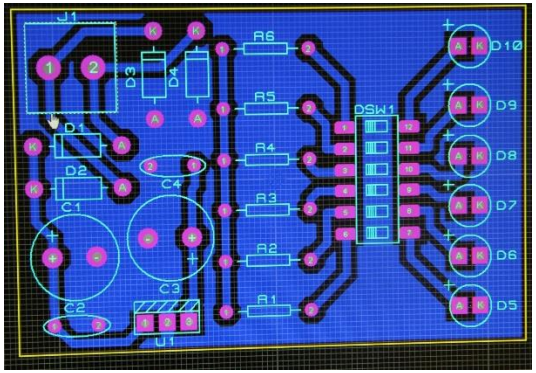
SMD Technology: Pick and Place Machine

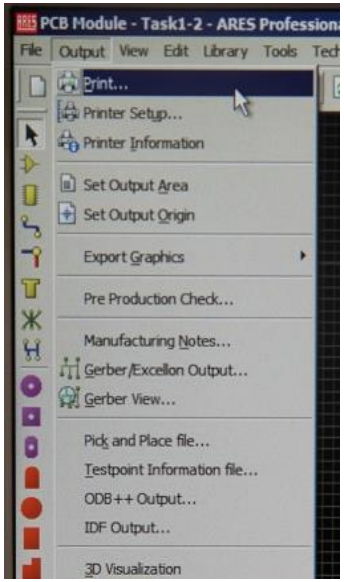
SMD Technology: Reflow Oven

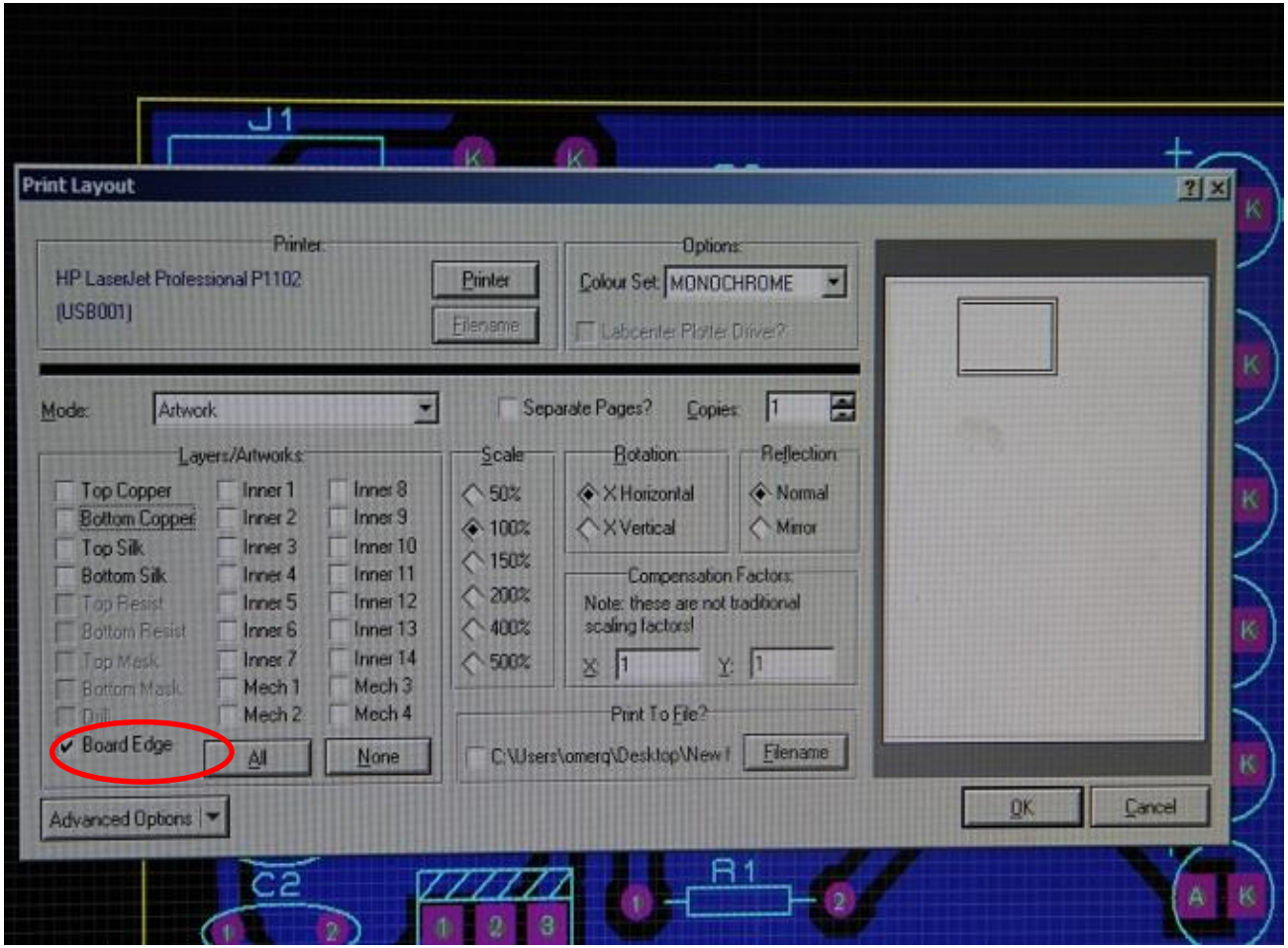


CONVENTIONAL PCB PROTOTYPING

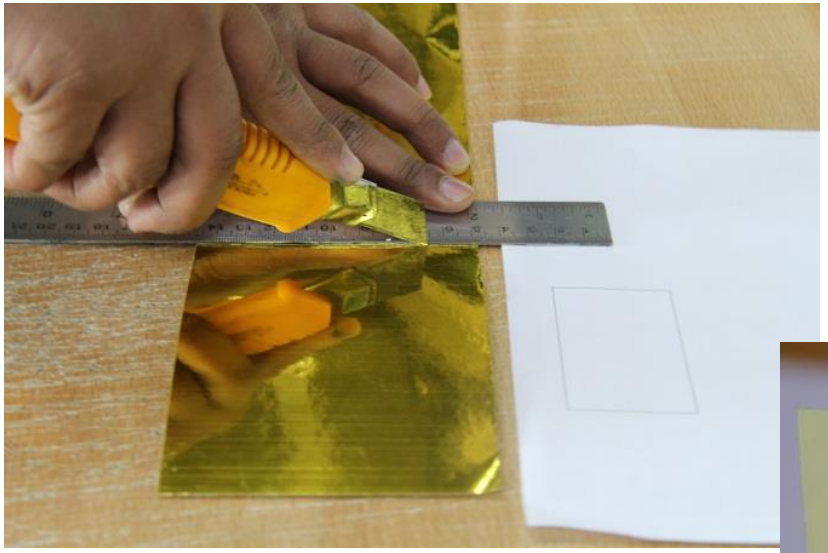
Print Outline for PCB Cutting



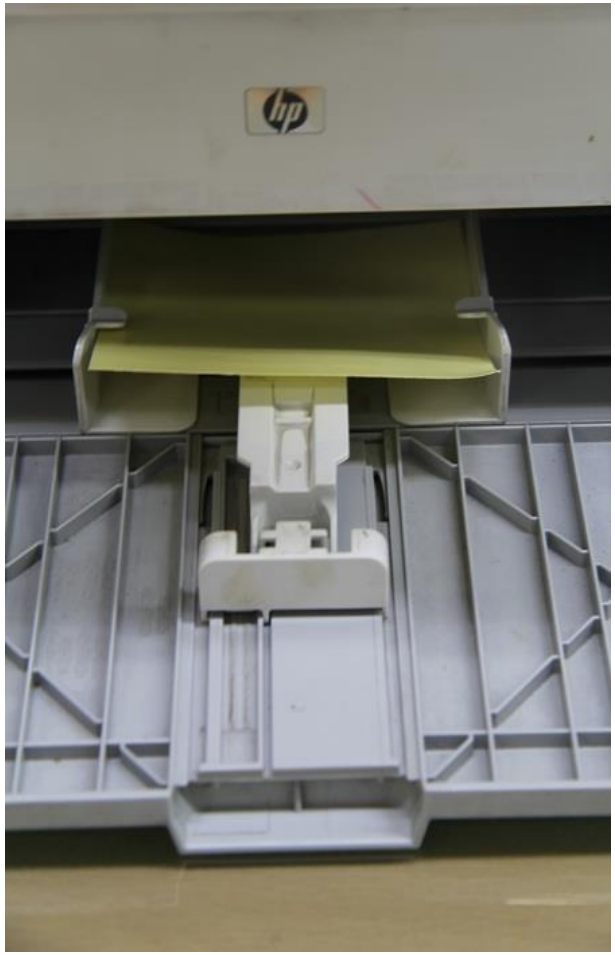


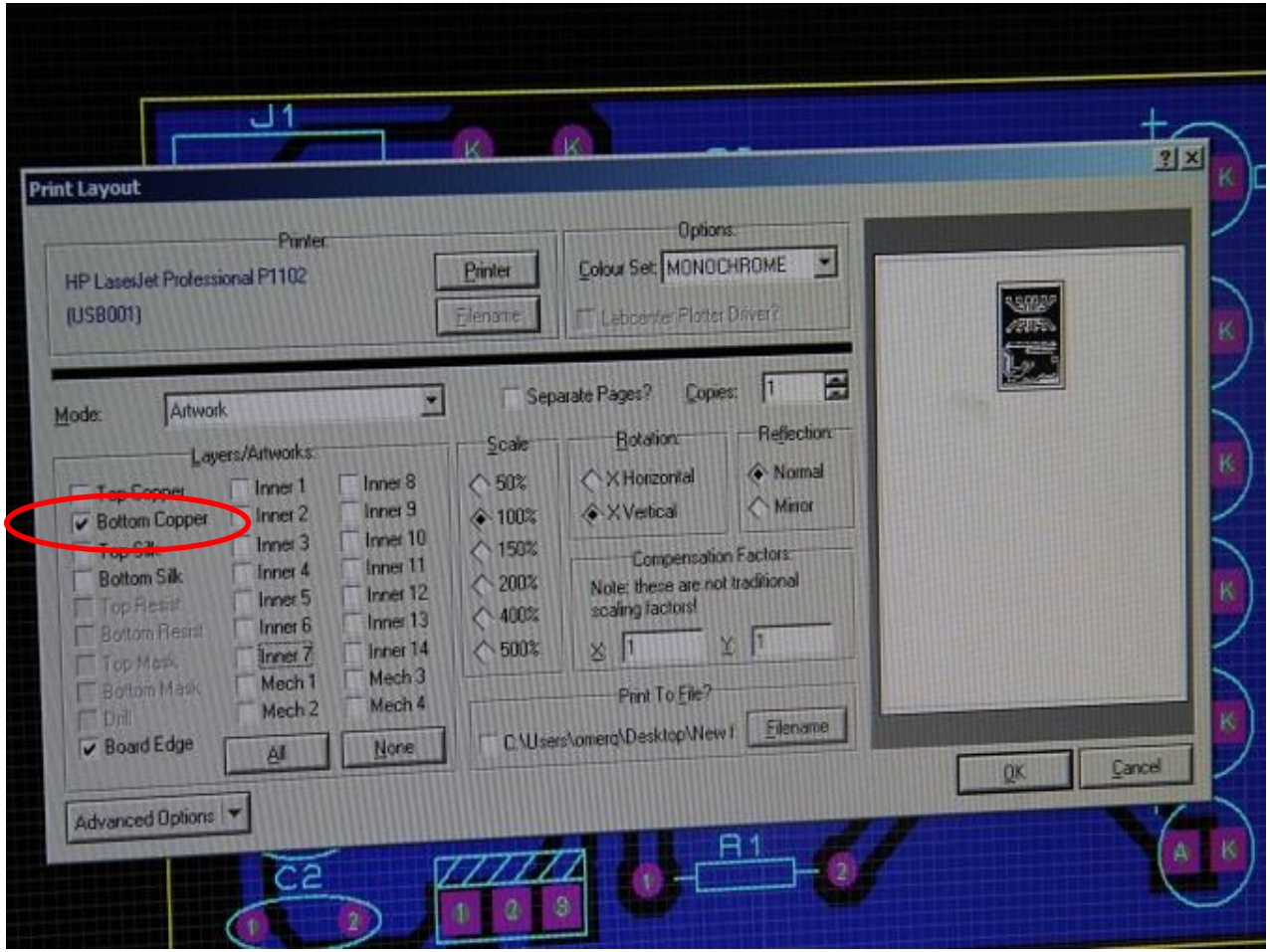


Cut Butter Paper / Peel Off Sticker Side

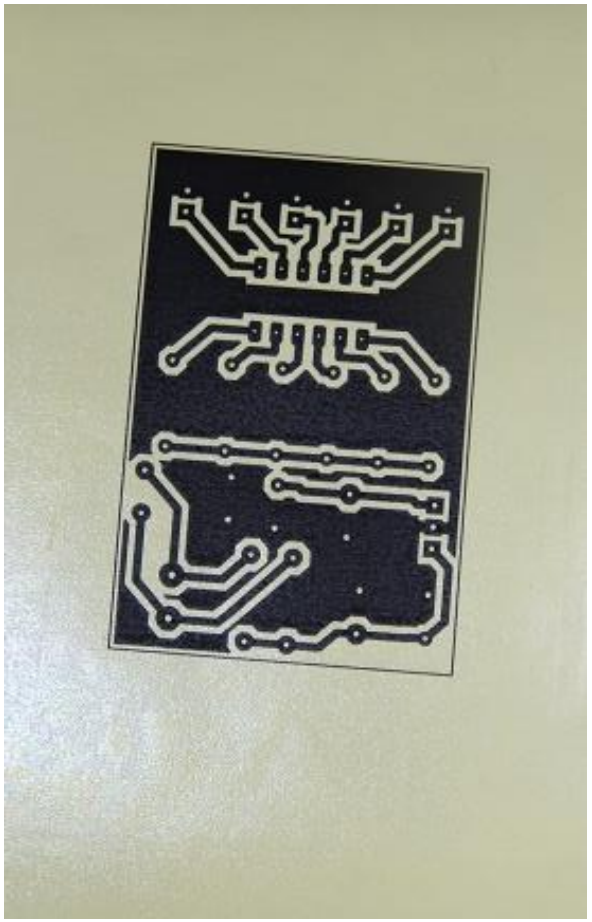


Print Layout using Laser Printer

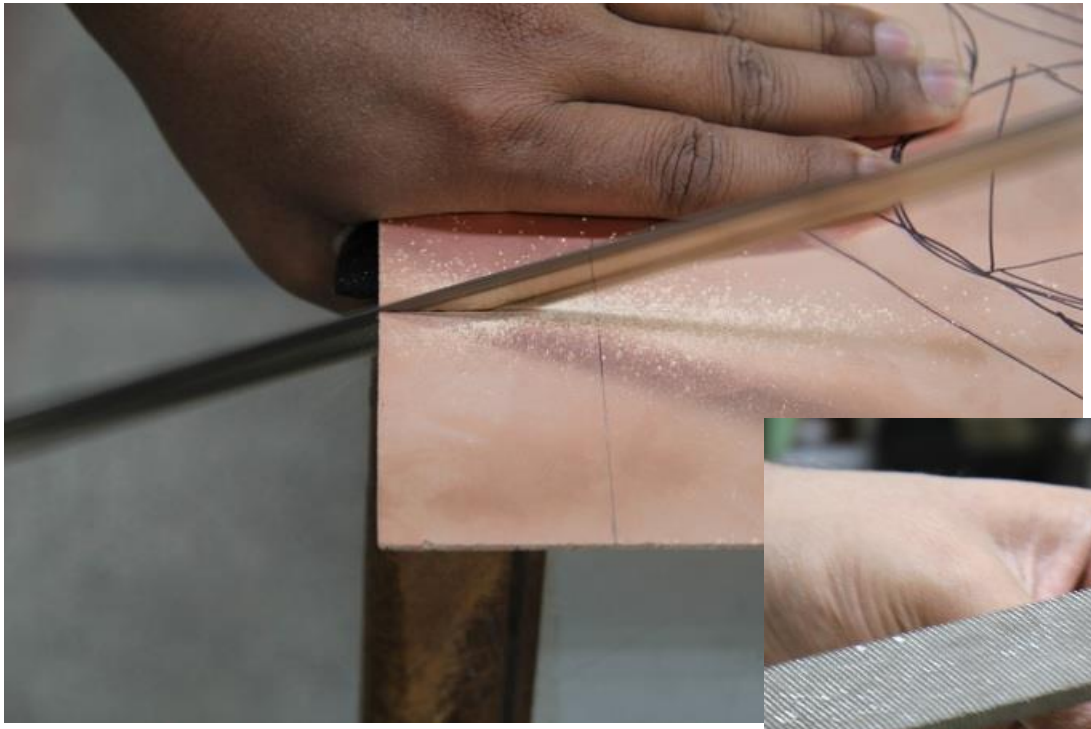




Negative Image of Printed Layout

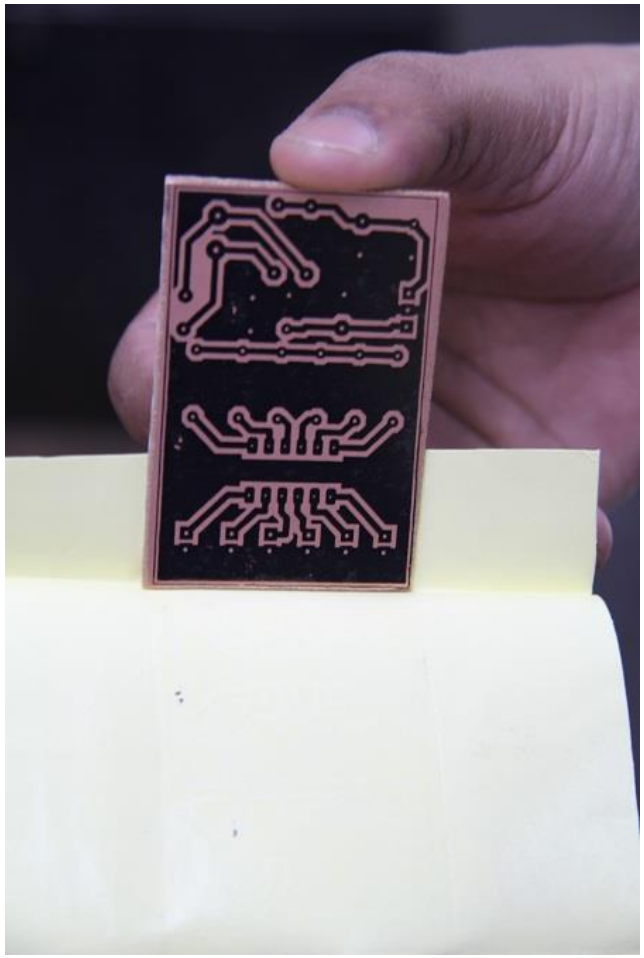


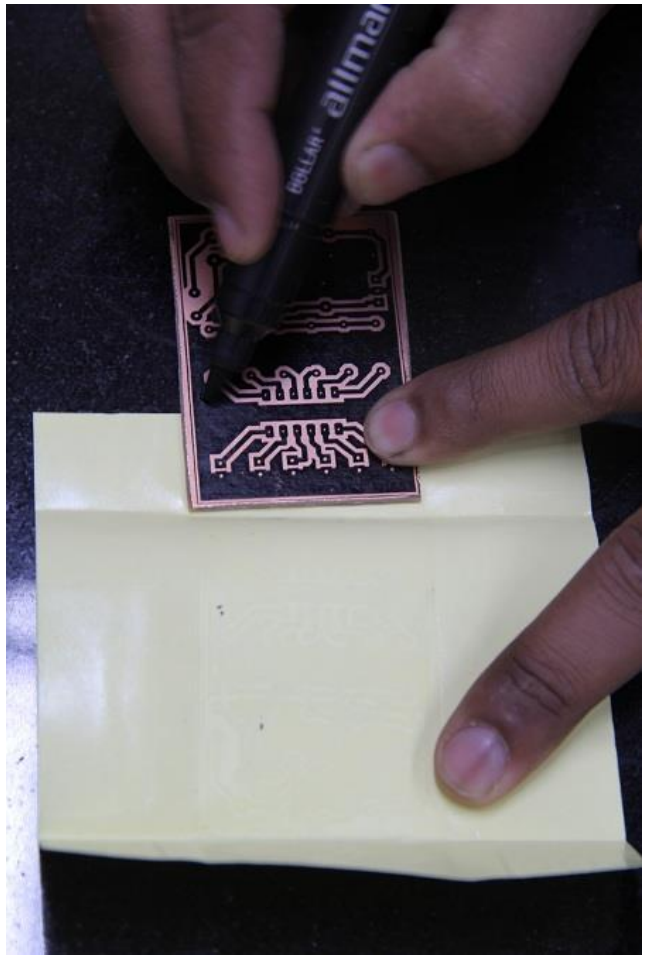
Cut/File PCB Board



Transfer Layout Image on PCB

Ink Transferred on PCB



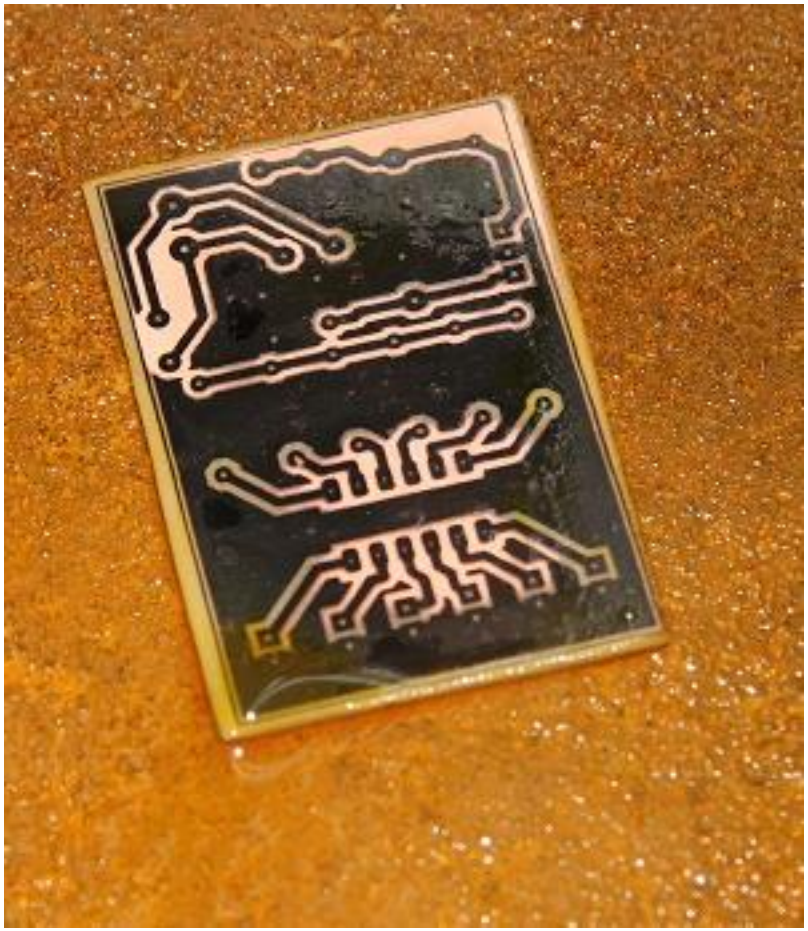


Use Hot Water and FeCl3

Fecl3 and PCB Inside Etching Tank

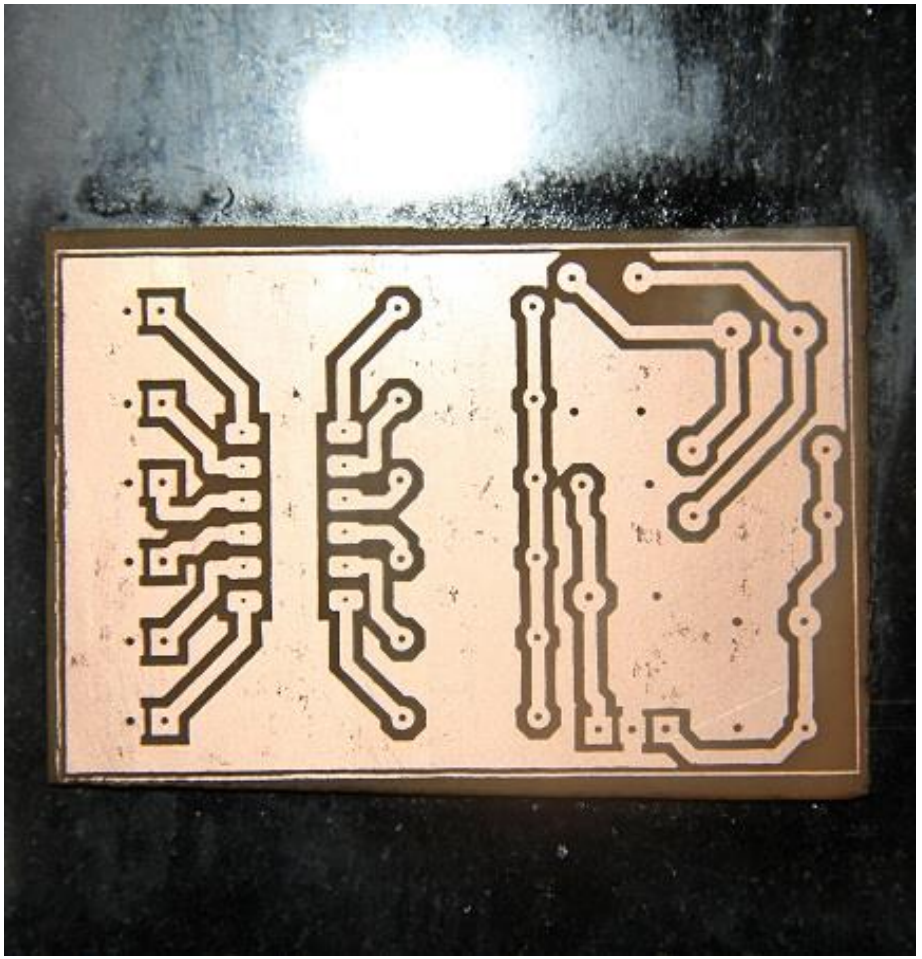
Add boiling water into the tank and stir the solution

Exposed copper is being dissolved into FeCl3 solution

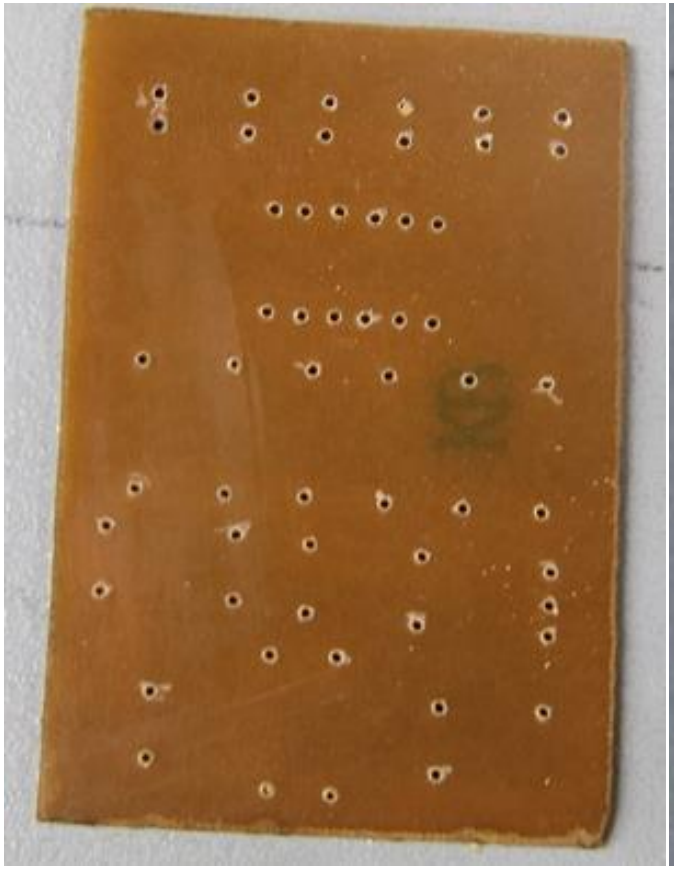


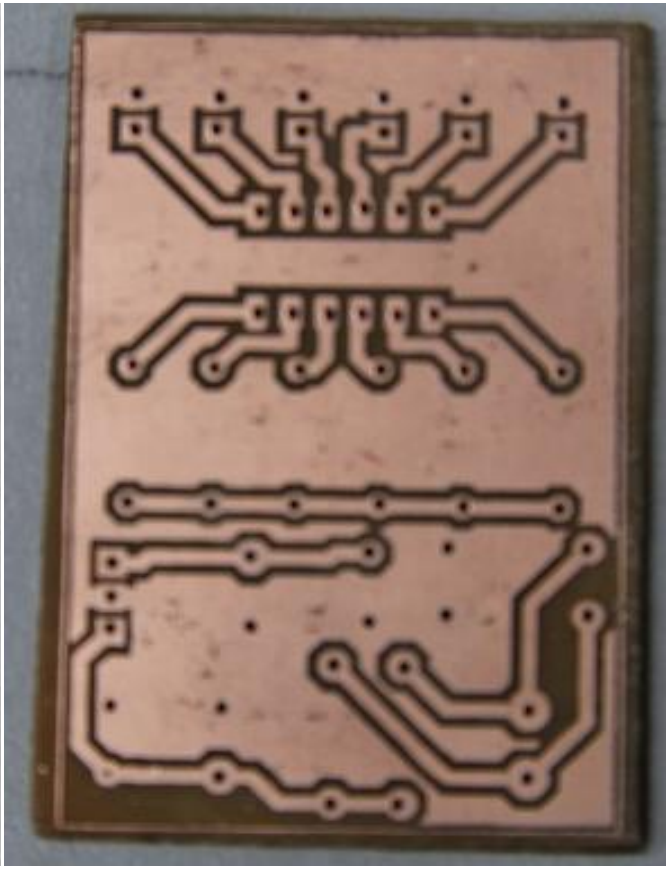
Wash after Etching

Use Petrol to remove Printer Ink from Etched PCB



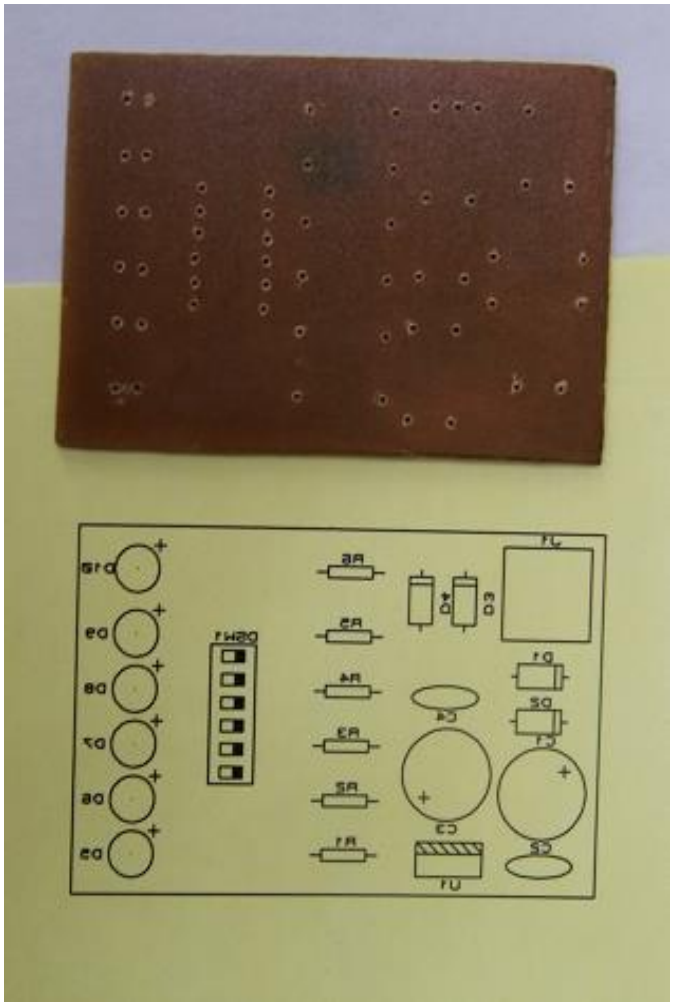
Hand Drilling



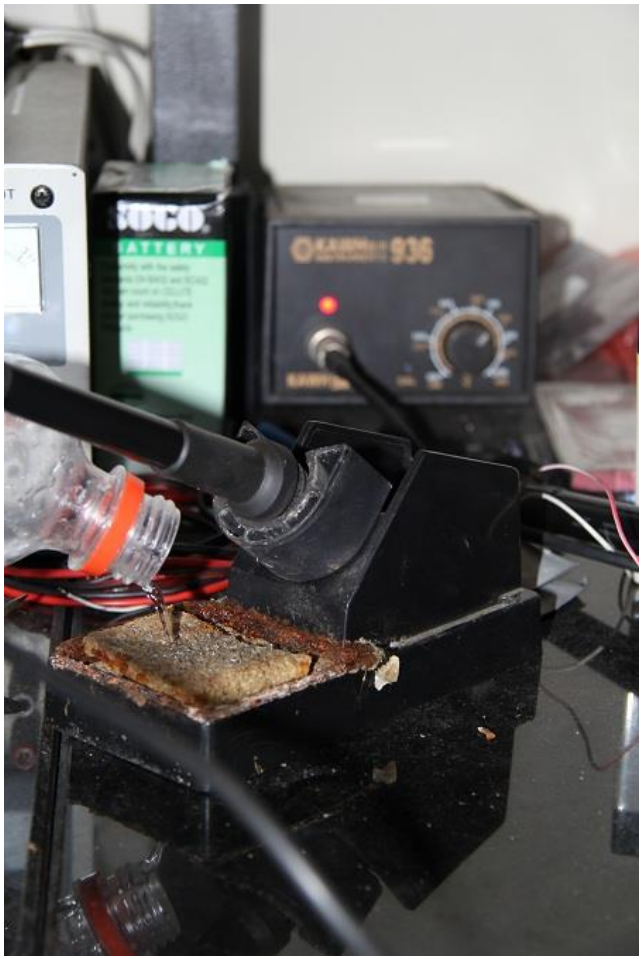


Prepare Butter Paper for Silk Screen Printing

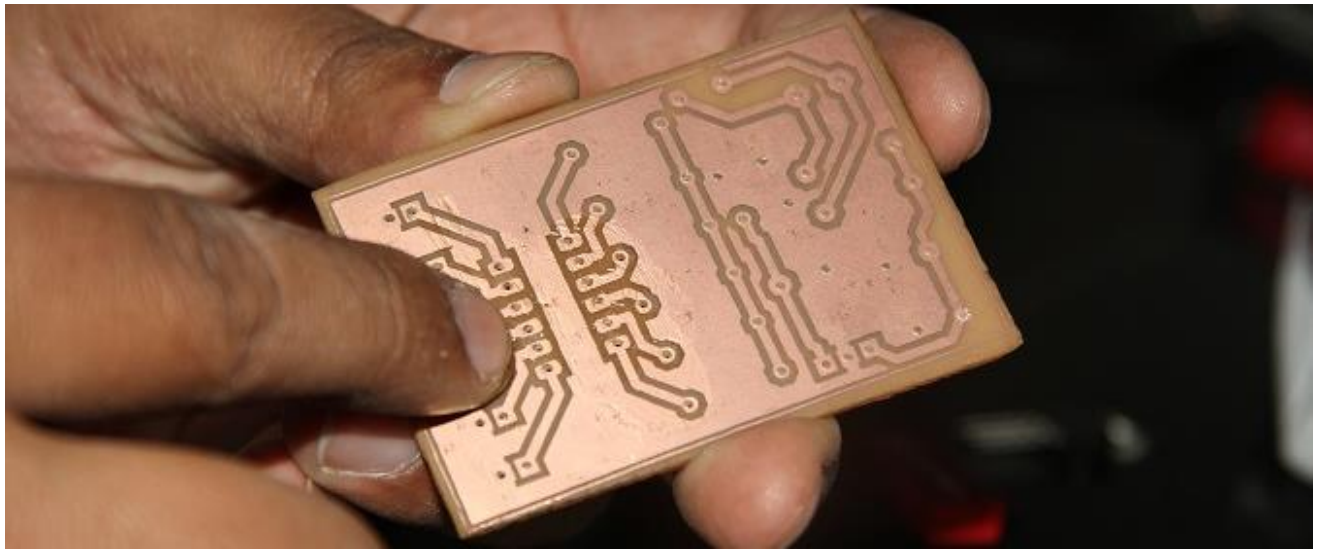
Transfer Silk Screen on PCB

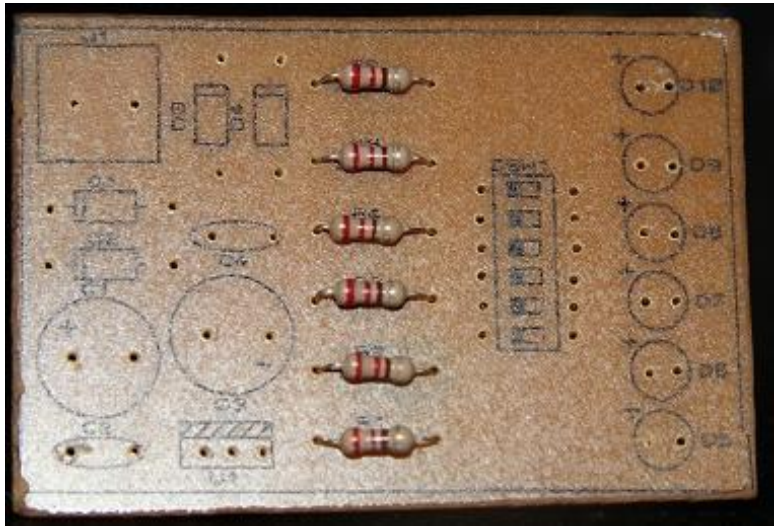


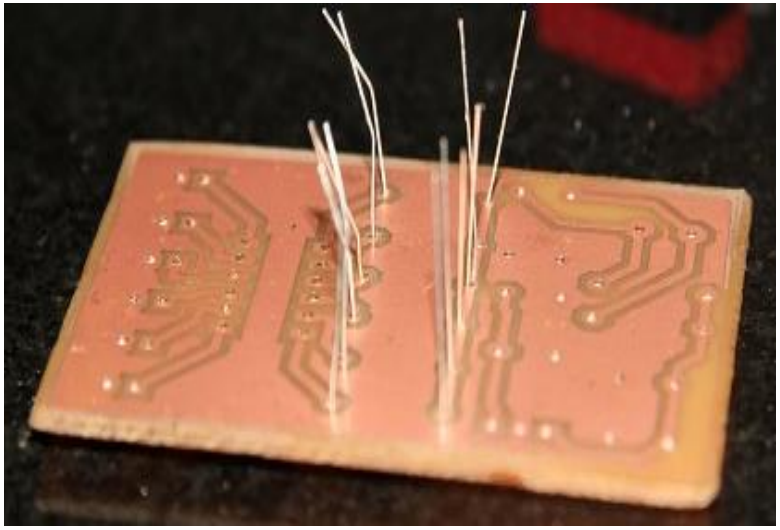
Prepare Soldering Work Station



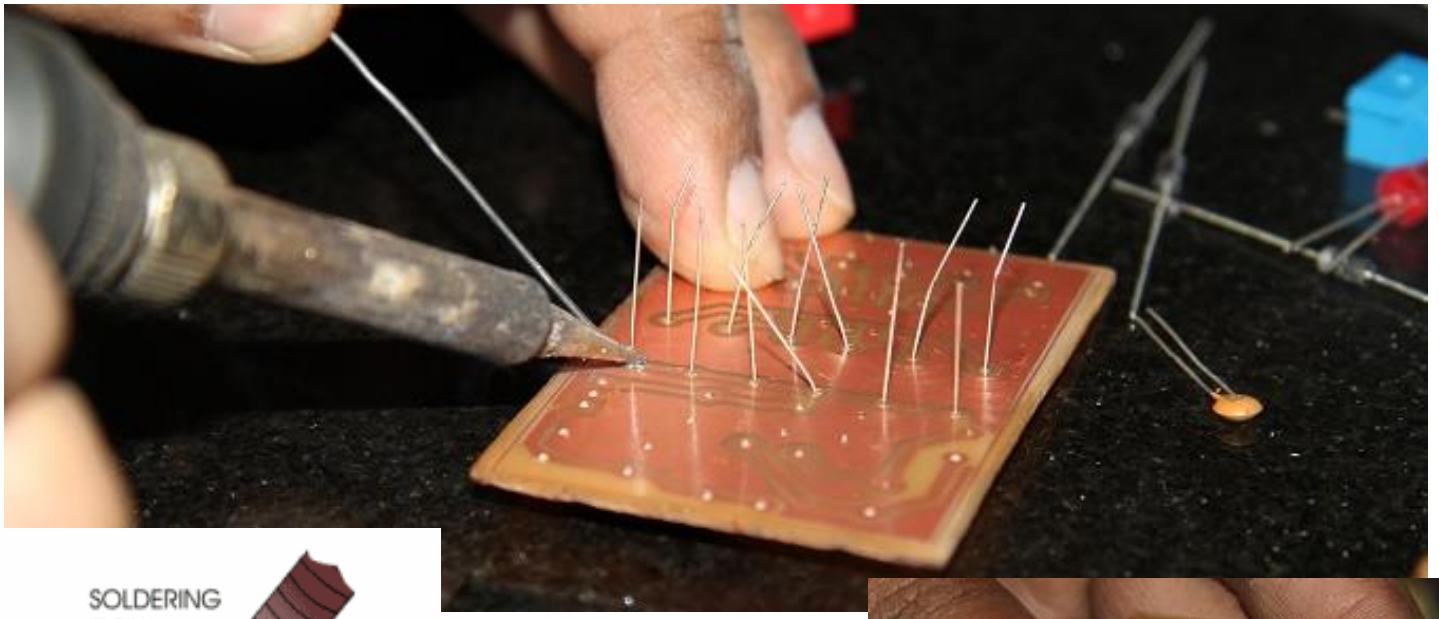
Apply Soldering Paste and Embed Resistors

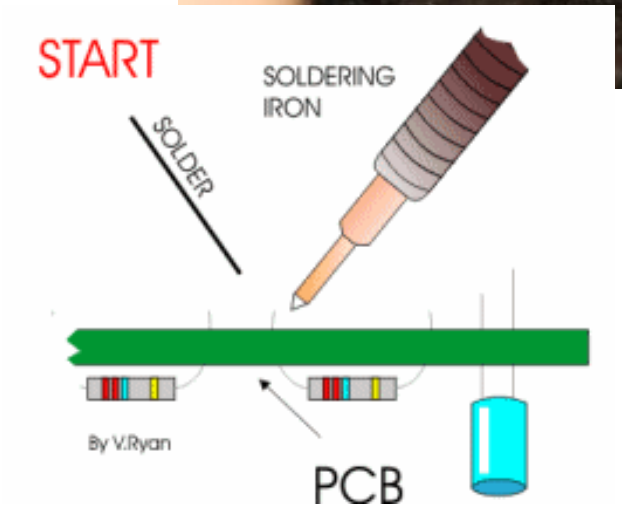




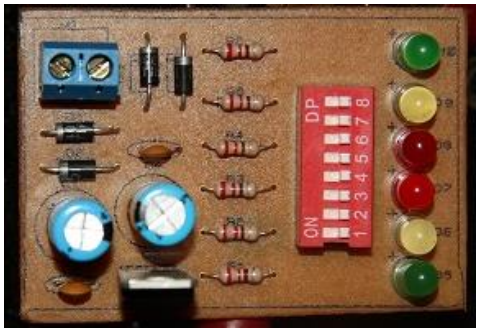


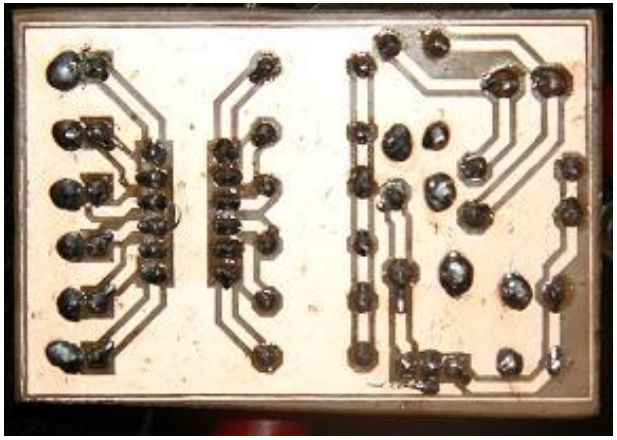
Solder Component Legs



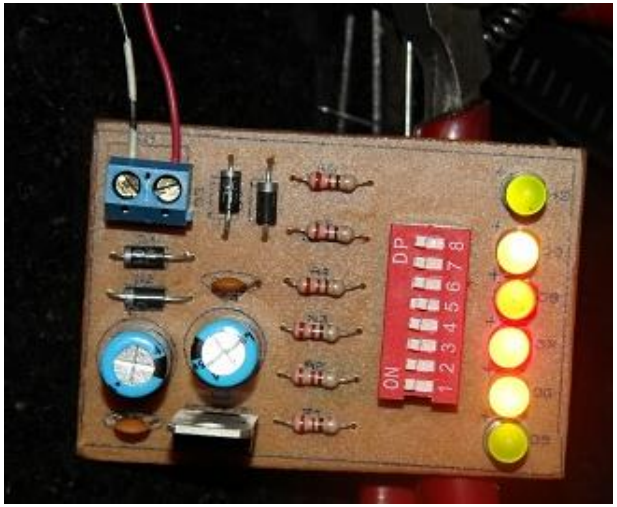


Solder Components (Smaller to Bigger)



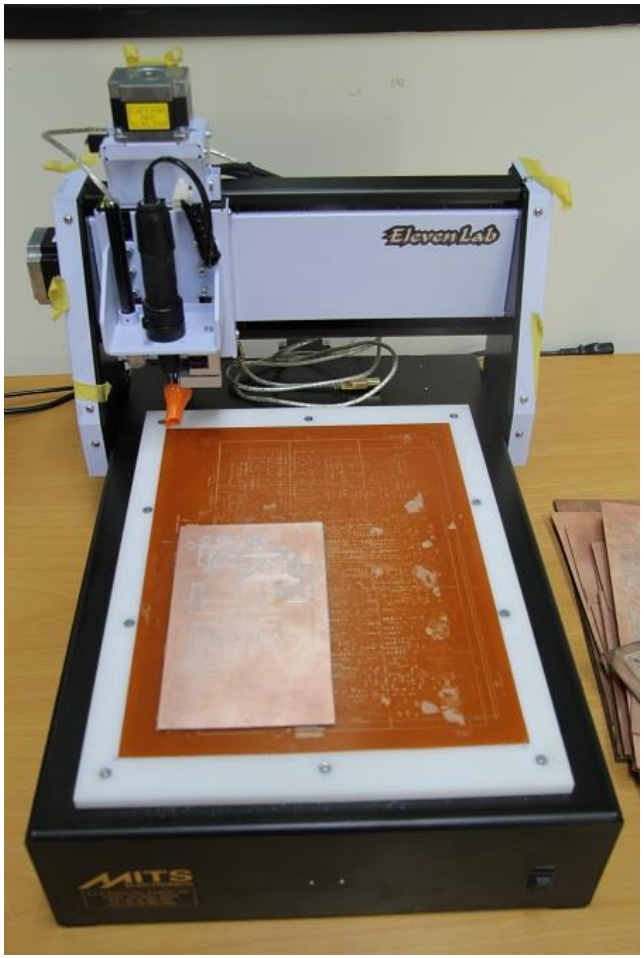


Testing (Power Up)

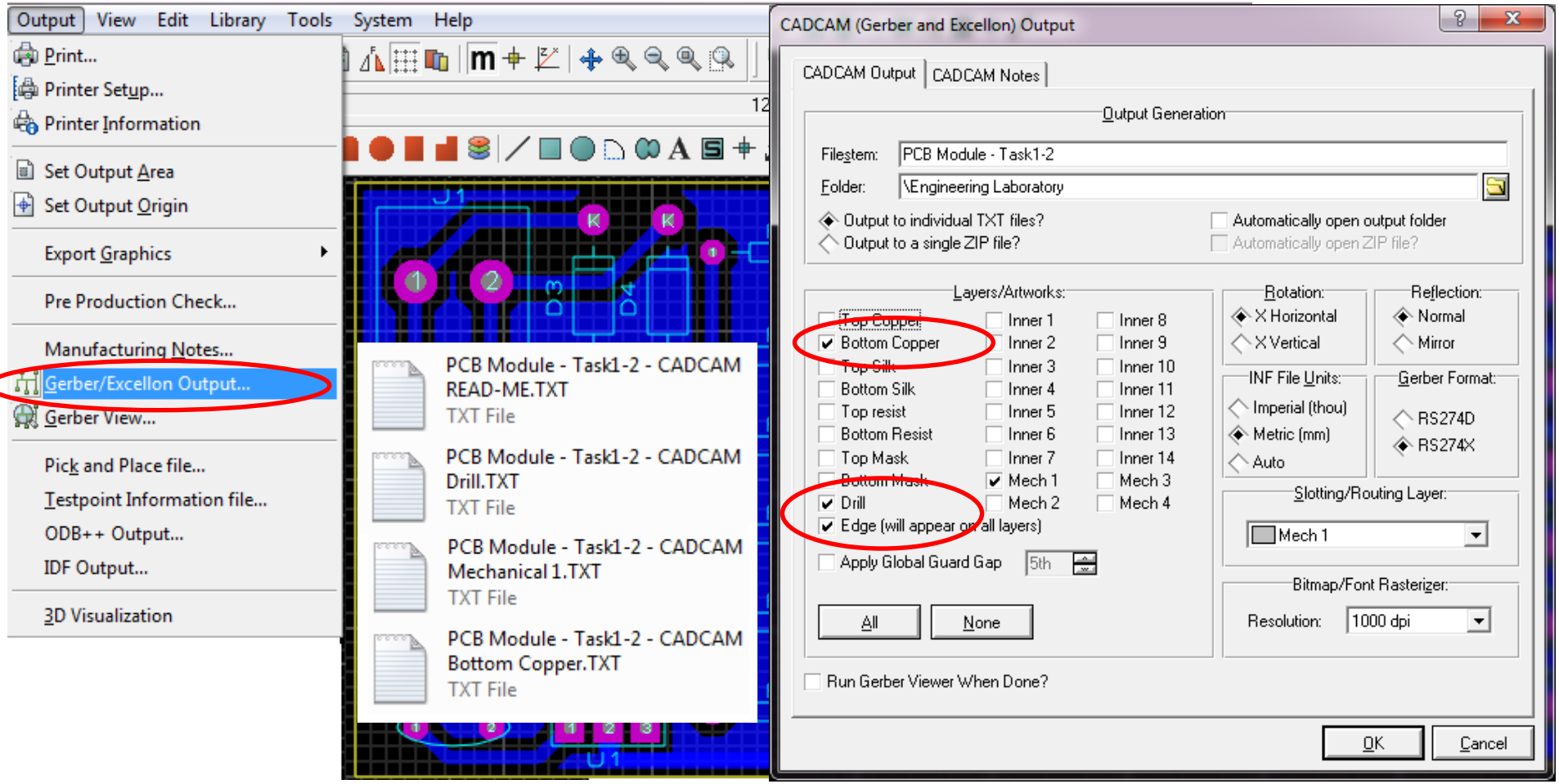


NON-CONVENTIONAL PCB PROTOTYPING

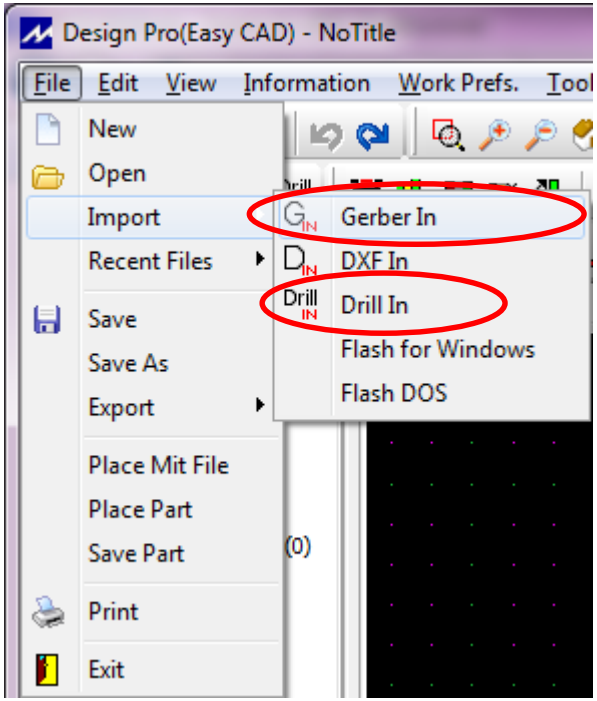
CNC Machine

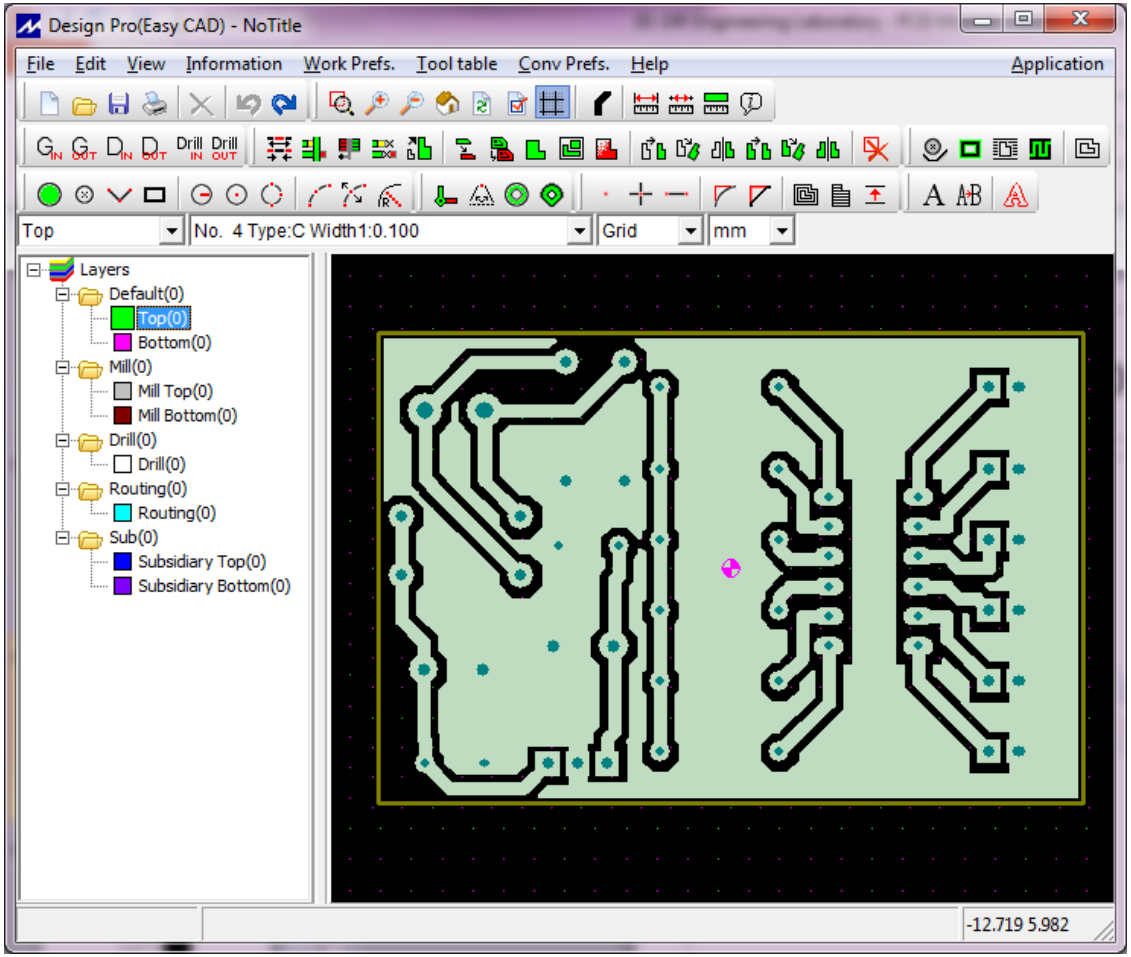


Create CAD/CAM Files

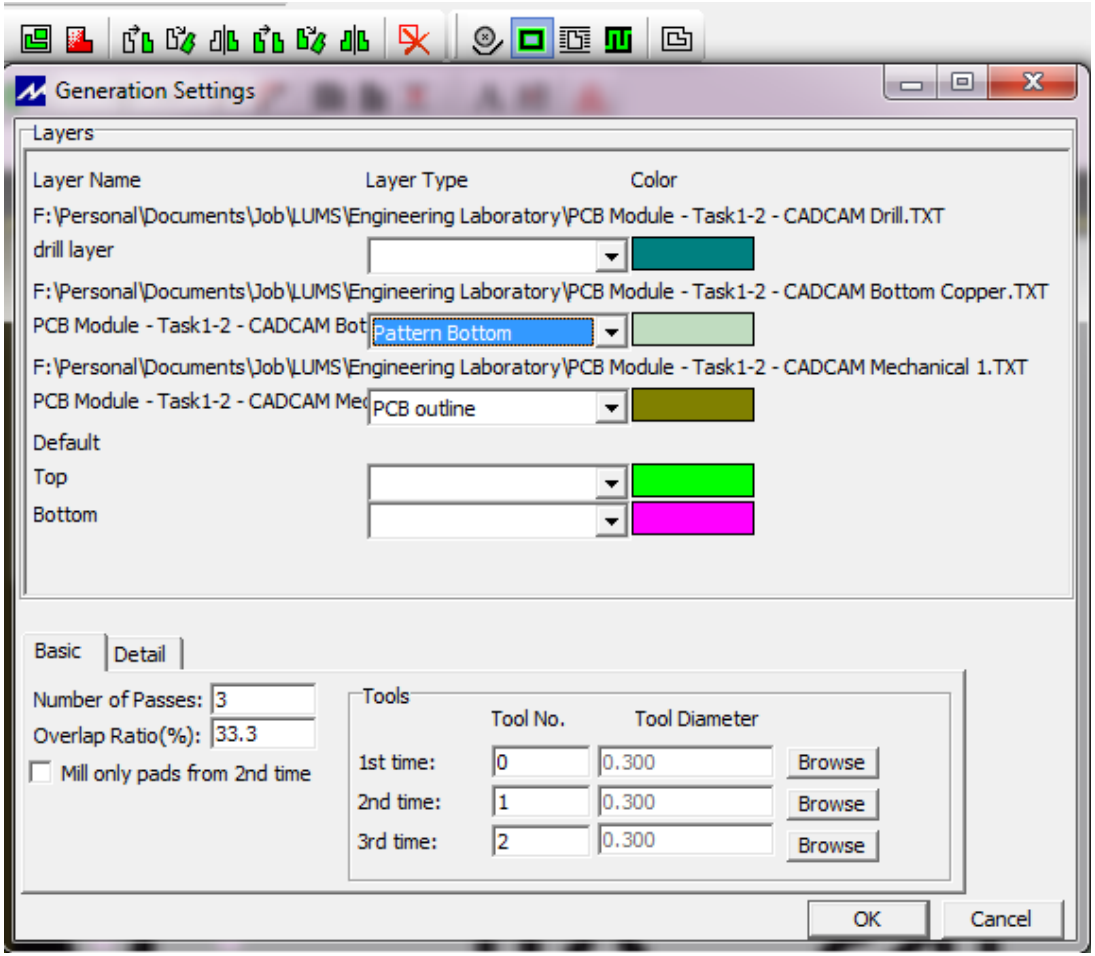


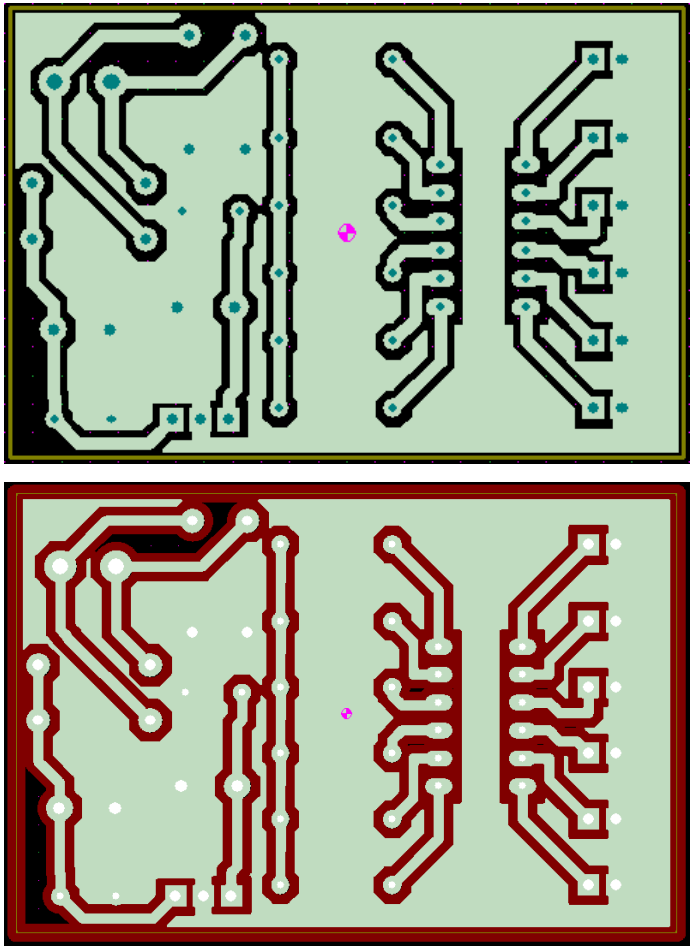
Import PCB Outline/Tracks/Drill Layer into CNC Machine Software



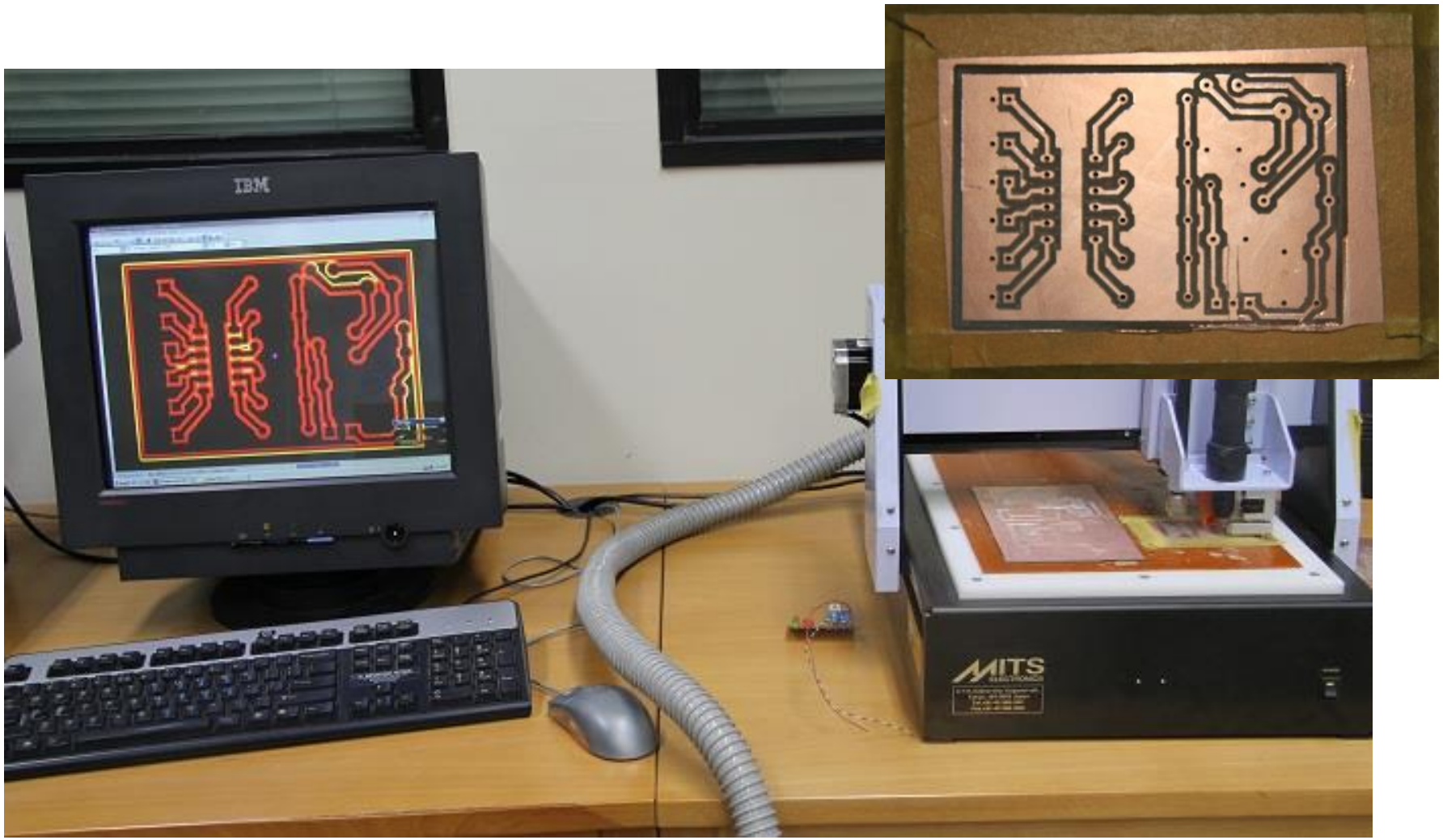


Create Drilling Marks and Milling Outlines

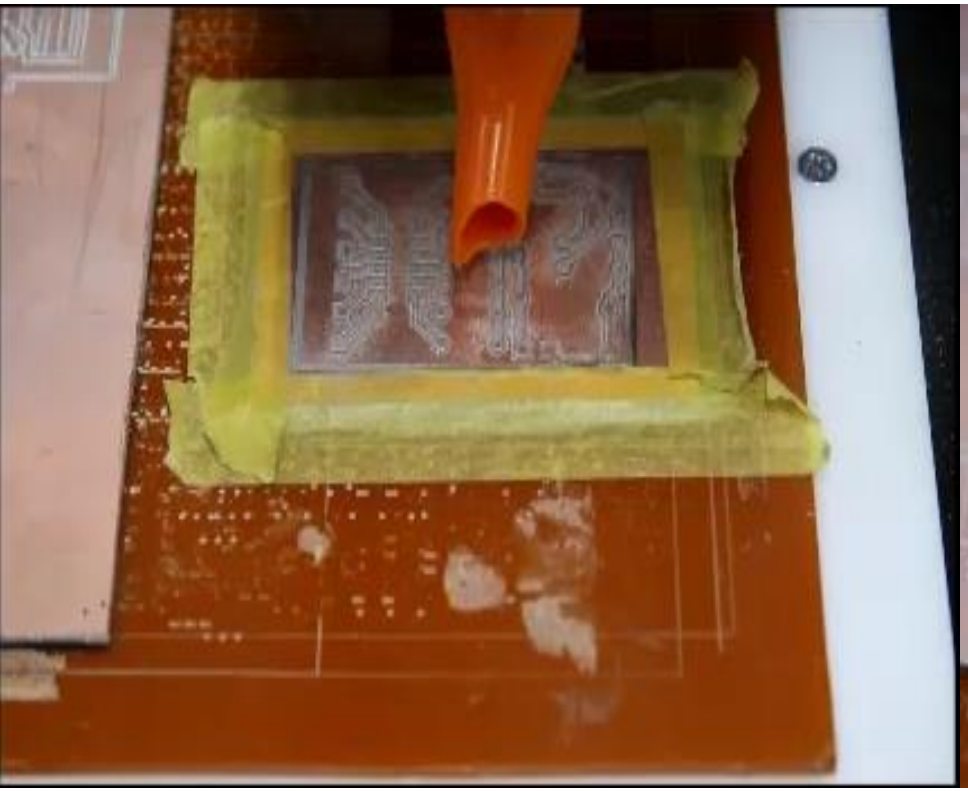




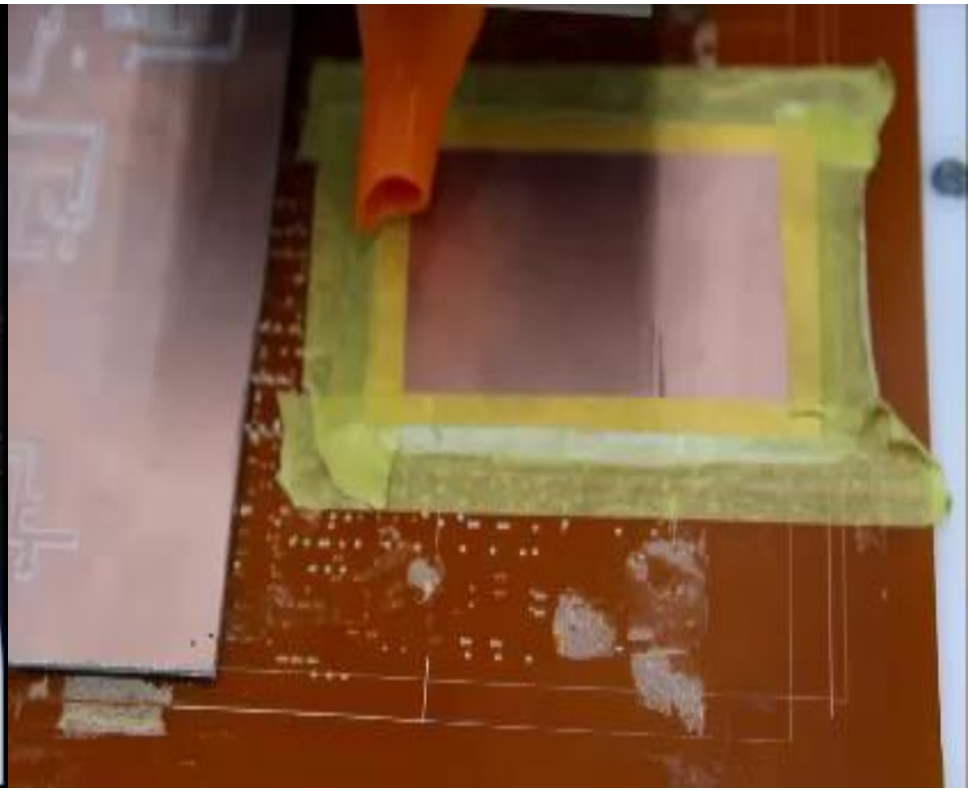
Final Output



Video Demonstration



PCB Drilling



PCB Milling

Lab Visit

- Conventional PCB Prototyping

- Non-Conventional PCB Prototyping