RAPID PROTOTYPING FOR AN EDUKIT USING 3D PRINTER AND CNC MACHINE

By

MD BILLAL HOSSAIN

POST GRADUATE DIPLOMA IN INFORMATION AND COMMUNICATION TECHNOLOGY

Institute of Information and Communication Technology (IICT)

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY

March, 2019

The project titled "RAPID PROTOTYPING FOR AN EDUKIT USING 3D PRINTER AND CNC MACHINE. " submitted by MD. BILLAL HOSSAIN, Student ID: 0412311012, Session: April-2012 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Post Graduate Diploma (ICT) held on **31th March 2019**.

BOARD OF EXAMINERS

1. **Dr. Md. Liakot Ali** — Chairman
   Professor
   IICT, BUET, Dhaka.
   (Supervisor)

2. **Dr. Md. Rubaiyat Hossain Mondal** — Member
   Associate Professor
   IICT, BUET, Dhaka.

3. **Dr. Shahin Akhter** — Member
   Assistant Professor
   IICT, BUET, Dhaka.

CANDIDATE'S DECLARATION

It is hereby declared that this project report or any part of it has not been submitted elsewhere for the award of any degree or diploma.

MD BILLAL HOSSAIN
Student ID: 0412311012
IICT, BUET, Dhaka.

Dedicated

To

My Family & My Honorable Teacher Prof. Dr. Md. Liakot Ali

Table of Contents

Title	Page no.
Top	i.
Board Of Examiners	ii.
Candidates Declaration	iii.
Dedication	iv.
Table of contents	v
List of figure	ix
List of Abbreviations	xii
Acknowledgement	xiii
Abstract	Xiv
Chapter 1: Introduction	1
1.1 Introduction	1
1.2 Objective with specific aims and possible output	2
1.3 Organization of the project report	2
Chapter 2: Fundamentals of PCB, CNC machine and 3D Printing Technology	3
2.1 Introduction	3
2.2 Printed Circuit Board (PCB)	3
2.2.1 Substrate (FR4)	4
2.2.2 Copper foil	5
2.2.3 Solder mask	6
2.2.4 Silkscreen	6
2.3 CNC machines	6
2.3.1 CNC machines working system	8
2.3.2 Types of CNC Machines	8
2.2.3 Novel Technologies	9
2.2.4 Materials Used	9
2.3 About 3D Printing	9
2.3.1 Software for 3D	10
2.3.2 Firmware and electronics interface	10

2.3.3 Hardware 10
2.4 Application for Rapid Prototyping 11
2.5 Comparison between CNC and 3D Printing 11
Chapter 3: Design and Implementation of the Edukit using 3D Printing Technology 12
3.1 Introduction 12
3.2 Requirement Gathering, Specification and Planning 12
3.3 PCB design by CNC machine 12
3.4 Casing design by 3D printing 13
3.5 Hardware Requirements list 13
3.6 Software Requirements list 14
3.7 Schematic design by EAGLE platform 14
3.8 Schematic Design with Eagle PCB Design Tool 16
3.9 Schematic design 17
3.10 generate of PCB board 17
3.11CopperCAM Software 18
3.12 G-code generate 19
3.13 PCB printing by CNC machine 20
3.14 G-code 20
3.13.1 Machine Motion 22
3.13.2 Miscellaneous Codes 22
Chapter 4: Result and discussion 24
4.1 Introduction 24
4.2 Schematic design of project CKT 24
4.3 Fabricate PCB using copperCAM Software 26
4.4 resulting G-code 27
4.5 CNC milling machine and its operation 27
4.6Works on CNC milling machine 28
4.7 CNC Spindle and Motor check 28
4.8 PCB Cutting 29
4.9 PCB Drilling 30
4.10 PCB Design output 31
4.11 Casing design using 3D printer 33

4.12 3D printer configurations 35
4.13 The Basic configuration of 3D print 35
4.13.1 KARIKA 3D Printer Display 37
4.13.2 Garber code generate 38
4.13.3 Object G- code generate 38
4.14 Object print 39
4.15 Some snapshot of BOX printing 40
4.16 Lid printing 42
4.17 Output of my product 46
4.18 Performance and Cost Comparison of traditional and 3D printing technology 47
Chapter 5: Conclusion 48
5.1 Conclusion 48
5.2 Suggestion for Future Work 48

List of Figure

Figure No	Figure Caption	Page no.
Figure 2.1	single sided printed circuit board	3
Figure 2.2	Different layers of PCB	4
Figure 2.3	FR4 layer of PCB	5
Figure 2.4	A CNC machine.	7
Figure 3.1	Flowchart of a PCB design by CNC machine.	13
Figure 3.2	flowcharts for implementation of 3D printing.	13
Figure 3.3	EAGLE 7.5.0 software layout	15
Figure 3.4	The schematic design platform on EAGLE 7.5.0 version.	15
Figure 3.5	Add bottom and component list window on eagle software.	16
Figure 3.6	Schematic design of a PCB.	17
Figure 3.7	convert schematic to PCB board tool.	18
Figure 3.8	CopperCAM Software outlook.	18
Figure 3.9	Top layer of my CKT.	19
Figure 3.10	PRONTEFACE software outlook.	20
Figure 4.1	CKT schematic design.	24
Figure 4.2	Converted schematic design to PCB Board.	25
Figure 4.3	Generated PCB Board	25
Figure 4.4	Fabrication of PCBBoard (Bottom Layer)	26
Figure 4.5	Fabrication of PCB Board (Bottom Layer)	26
Figure 4.6	Printrun software outlook.	27
Figure 4.7	CNC milling machine bed.	27
Figure 4.8	setup PCB board on CNC machine**.**	28
Figure 4.9	Checking CNC motor speed and spindle	28
Figure 4.10	operational of CNC machine	29
Figure 4.11	Drilling a PCB by CNC machine	29
Figure 4.12	Drilling of PCB by CNC machine	30
Figure 4.13	Drilling monitoring of PCB by CNC machine	30
Figure 4.14	Monitoring PCB milling on CNC machine	31

Figure 4.15	End of the drilling	31
Figure 4.16	Resulting PCB using CNC Milling Machine	32
Figure 4.17	360 fusion software outlooks	33
Figure 4.18	Layout of BOX	33
Figure 4.19	Layout of Lid	34
Figure 4.20	CURE Software layout	35
Figure 4.21	KARIKA 3D Printer configuration	36
Figure 4.22	KARIKA 3D Printer configuration.	37
Figure 4.23	KARIKA 3D Printer Display	37
Figure 4.24	G-code generate platform	38
Figure 4.25	G- code generates for box print.	38
Figure 4.26	BOX printing	39
Figure 4.27	Printer Display when BOX printing, its time 20minutes.	39
Figure 4.28-4.32	Some snapshot of BOX printing	40-42
Figure 4.33	re-configuration of 3D Printer	43
Figure 4.34	Lid printing	43
Figure 4.35-Figure 4.38	Some snapshot of BOX printing	44-45
Figure 4.39	casing print using 3D printer	46

List of Abbreviations

ICT	Information and Communication Technology
PCB	printed circuit boards
CNC	Computer Numeric Control
TTM	Time to market
3D	The quality of being three-dimensional
CAD	Computer-aided design

Acknowledgement

First of all, I would like to thank Almighty Allah, the most merciful, the most gracious, the source of knowledge and wisdom endowed to mankind, who provided me with the power of mind, strength, patience and capability to carry me through the work and enable me to complete this project.

I would like to thank my supervisor, Prof. Dr. Md. Liakot Ali, Professor, Institute of Information and Communication Technology, Bangladesh University of Engineering and Technology, Dhaka, Bangladesh for his kind, constant, and inspiring guidance and encouragement valuable advice and suggestions at all stages for preparing this report.

In completing this project, I have been fortunate to have help, support and encouragement from many of my friends. I would like to acknowledge them for their cooperation.

I would like to thank my family for their continuous support and inspiration throughout the whole period of this undertaking.

Abstract

Rapid prototyping for an electronic product is now a burning issue in the industrial world. The world is now a global village where business is very much competitive. Technology is rapidly changing. So if a product is invented but not brought in the market in the right time then market will be lost, whole R & D effort will be null and void which in turn creates huge revenue loss. 3D printing technology has been proved effective for rapid prototyping of electronic product. It does not require making any new tool for product development which saves a lot of time, money, and effort that would normally be spent on tooling the production line and getting an assembly process set up. In this project, an Educational Kit (EduKit) for teaching and learning of microcontroller has been designed and developed including its casing and PCB has been developed using the CNC machine and 3D printing facility of IICT as a case study in order to learning the technology. Eagle software has been used for schematic and PCB design. From the schematic design, G-code is generated and then it is fed to the CNC machine for PCB fabrication which is once sent to China for the said fabrication and took months to reach in hand. Casing of the EduKit is designed using fusion 360 CAD software and from the CAD design G-code is again generated to feed the 3D printer. 3D printer slices the whole design using two a number of dimensional planes and exact amount of resource is used and the casing of the product is manufactured within shortest possible time. In future the 3D printing technology available in IICT, BUET can be used for commercial product development.

Chapter 1

Introduction

1.1 Introduction

This is an era of Information and Communication Technology (ICT) [1]. Now a day everywhere in the world people are using smart electronic products. Major revenues of the developed country are coming from their development of smart electronic products. It has been forecasted each person on the earth will use at least five electronic products on an average [2]. However time to market for an electronic product is now a big issue. The world is now a global village and business market is always competitive and technology is rapidly changing. If a product is developed but not brought in the market timely then other person/company will bring the similar product and occupy the market and thereby the whole opportunities will go in vain.

3D printing or Additive Manufacturing (AM) is now the key enabling technology for rapid prototyping of a product [3]. In AM the 3D printer uses a computer-aided design (CAD)to translate the design into a three-dimensional object. The design is then sliced into several two dimensional planes, which instruct the 3-D printer where to deposit the layers of material [3-4].One of the biggest advantages that 3D printing over traditional manufacturing is that the 3D printing process generally doesn't require any special new tooling to make a part. When making a prototype, this can save a lot of time, money, and effort that would normally be spent on tooling the production line and getting an assembly process set up [4-5]. Moreover 3D printing is incredibly resource-efficient. Here the only material that is consumed is what passes through the extruder of the printer, which is used for the actual assembly of the product [6]. Currently, manufacturing industries in the world are moving towards 3D printing for any product with low-volume, high-unit cost and the rapid need for customization. So learning and Skills over 3D model can generate huge revenue for our country. In this project, a complete prototype of an Edukit including its casing and PCB has been developed using the CNC machine and 3D printing facility of IICT as a case study in order to learning the technology.

1.2 Objective with specific aims and possible output

The objective of this project is rapid prototyping of an electronic product using and CNC machine and 3D printing technology. It has the following aims:

(i) To design a printed circuit board for an Educational Kit for learning PIC micro controller
(ii) To fabricate the PCB using CNC machine
(iii) To design 3 D model of the platform and casing of the Edukit and then develop the product

The outcome of this project is a prototype of an Educational Kit for learning PIC micro controller

1.4 Organization of the project report

The report has been written in chapter 5. First chapter contains the introduction about rapid prototype for EduKit using CNC machine and 3D printer, Objectives of the project etc. second chapter consists of General Discussion about PCB, CNC machine, 3D printers etc. third chapter of the report contains requirements for your product , necessary Tools (hardware and software) used in your product. Fourth chapter is the result, outcome and discussions parts of the project. Fifth chapter is the conclusion and recommendation of future works.

Chapter 2

Fundamentals of PCB, CNC machine and 3D Printing Technology

2.1 Introduction

This chapter briefly describes about the PCB, CNC machine and 3-D printing technology. These technologies have been used for the proposed rapid prototyping of the said EduKit including casing and PCB. It will help to develop a background for the reader to understand the report.

2.2 Printed Circuit Board (PCB)

Printed Circuit Board can be shortly called as PCB. PCB is a non-conductive substrate that mechanically supports and electrically connects the electronic components using tracks, pads and other features etched on a laminated copper sheet. PCBs can be a Single-sided (one copper layer), Double-sided (two copper layers) and Multilayer.Printed circuit board is the most common name but may also be called "printed wiring boards" or "printed wiring cards". Before the advent of the PCB circuits were constructed through a laborious process of point-to-point wiring. This led to frequent failures at wire junctions and short circuits when wire insulation began to age and crack. Figure: 2.1 shows a single side pcb board.

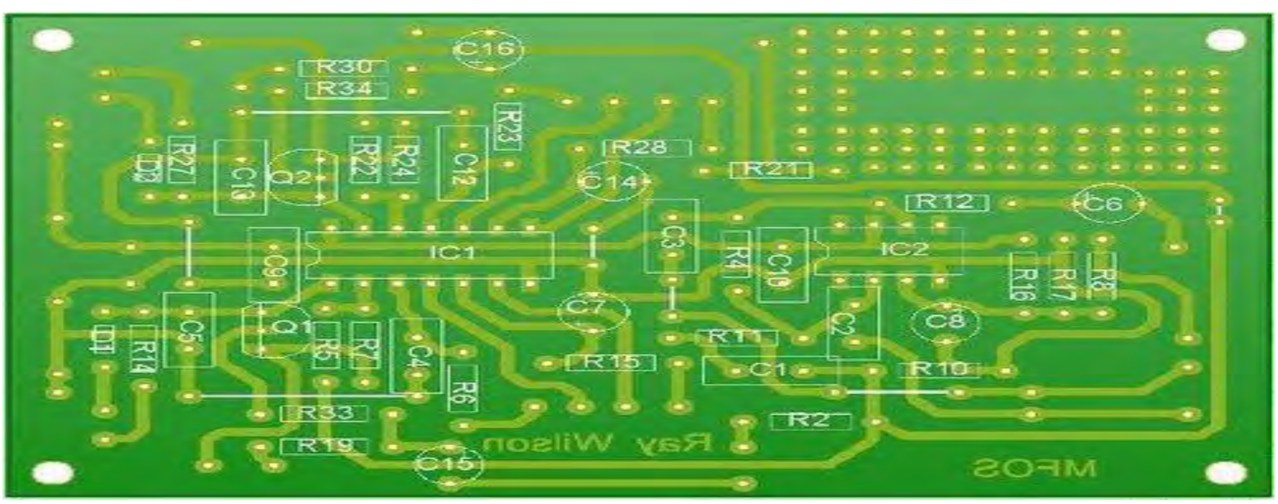

Figure 2.1: Single sided printed circuit board

A significant advance was the development of wire wrapping, where a small gauge wire is literally wrapped around a post at each connection point, creating a gas-tight connection which is highly durable and easily changeable.

As electronics moved from vacuum tubes and relays to silicon and integrated circuits, the size and cost of electronic components began to decrease. Electronics became more prevalent in consumer goods, and the pressure to reduce the size and manufacturing costs of electronic products drove manufacturers to look for better solutions. Thus was born the PCB.PCB is an acronym for printed circuit board. It is a board that has lines and pads that connect various points together. In the picture above, there are traces that electrically connect the various connectors and components to each other. A PCB allows signals and power to be routed between physical devices. Solder is the metal that makes the electrical connections between the surface of the PCB and the electronic components. Being metal, solder also serves as a strong mechanical adhesive.A PCB is sort of like a layer cake or lasagna- there are alternating layers of different materials which are laminated together with heat and adhesive such that the result is a single object.Figure 2.2 shows different layers of Printed circuit board.

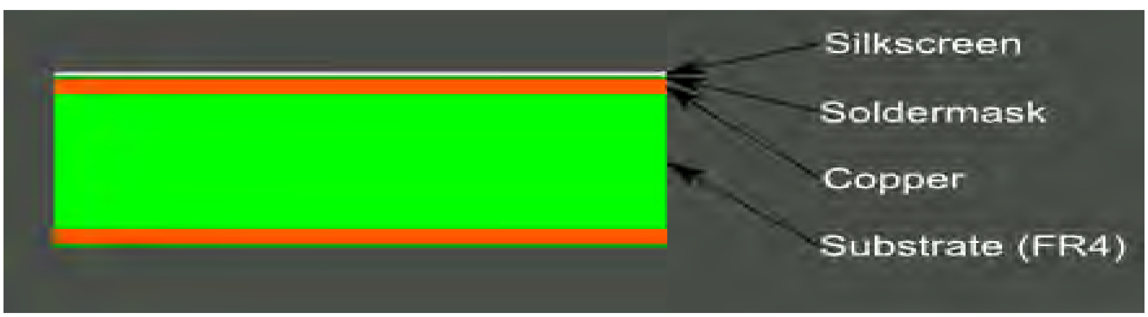

Figure 2.2: Different layers of PCB

2.2.1 Substrate (FR4)

The base material, or substrate, is usually fiberglass. Historically, the most common designator for this fiberglass is "FR4". This solid core gives the PCB its rigidity and thickness. There are also flexible PCBs built on flexible high-temperature plastic (Kempton or the equivalent).

You will find many different thickness PCBs; the most common thickness for SparkFun products is 1.6mm (0.063"). Some of our products- LilyPad boards and Arudino Pro Micro boards- use a 0.8mm thick board. Figure 2.3 Show the PCB Substrate (FR4) layer.

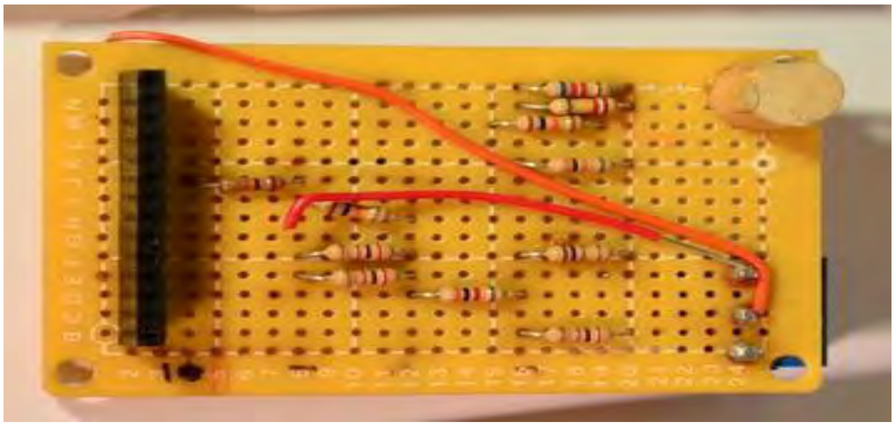

Figure 2.3: FR4 layer of PCB

Cheaper PCBs and perf boards (shown above) will be made with other materials such as epoxies or phenolics which lack the durability of FR4 but are much less expensive. You will know you are working with this type of PCB when you solder to it - they have a very distictive bad smell. These types of substrates are also typically found in low-end consumer electronics. Phenolics have a low thermal decomposition temperature which causes them to delaminate, smoke and char when the soldering iron is held too long on the board.

2.2.2 Copper foil

The next layer is a thin copper foil, which is laminated to the board with heat and adhesive. On common, double sided PCBs, copper is applied to both sides of the substrate. In lower cost electronic gadgets the PCB may have copper on only one side. When we refer to a double sided or 2-layer board we are referring to the number of copper layers (2) in our lasagna. This can be as few as 1 layer or as many as 16 layers or more.

PCB with copper exposed, no solder mask or silkscreen.

The copper thickness can vary and is specified by weight, in ounces per square foot. The vast majority of PCBs have 1 ounce of copper per square foot but some PCBs that handle very high power may use 2 or 3 ounce copper. Each ounce per square translates to about 35 micrometers or 1.4 thousandths of an inch of thickness of copper.

2.2.3 Solder mask

The layer on top of the copper foil is called the soldermask layer. This layer gives the PCB its green (or, at SparkFun, red) color. It is overlaid onto the copper layer to insulate the copper traces from accidental contact with other metal, solder, or conductive bits. This layer helps the user to solder to the correct places and prevent solder jumpers.

In the example below, the green solder mask is applied to the majority of the PCB, covering up the small traces but leaving the silver rings and SMD pads exposed so they can be soldered to.

Soldermask is most commonly green in color but nearly any color is possible. We use red for almost all the SparkFun boards, white for the IOIO board, and purple for the LilyPad boards.

Silkscreen

2.2.4 Silkscreen

The white silkscreen layer is applied on top of the solder mask layer. The silkscreen adds letters, numbers, and symbols to the PCB that allow for easier assembly and indicators for humans to better understand the board. We often use silkscreen labels to indicate what the function of each pin or LED.

Silkscreen is most commonly white but any ink color can be used. Black, gray, red, and even yellow silkscreen colors are widely available; it is, however, uncommon to see more than one color on a single board.

2.3**CNC machines**

CNC is the short form for Computer Numerical control. We have seen that the NC machine works as per the program of instructions fed into the controller unit of the machine. The CNC machine comprises of the mini computer or the microcomputer that acts as the controller unit of the machine. While in the NC machine the program is fed into the punch cards, in CNC machines the program of instructions is fed directly into the computer via a small board similar to the traditional keyboard. CNC Machine is a generally used in the manufacturing sector that involves the use of computers to control machine tools. Tools that can be controlled in this manner include milling, and drilling. The CNC stands for Computer Numerical Control. From this CNC technology, the biggest change in the world of digital electronics & Micro-controller. It uses three stepper motors as linear actuators on each axis X, Y & Z. While printing, the proper synchronization of this entire three axis.

In CNC machine the program is stored in the memory of the computer. The programmer can easily write the codes, and edit the programs as per the requirements. These programs can be used for different parts, and they don’t have to be repeated again and again. figure 2.4 shows a CNC machine.

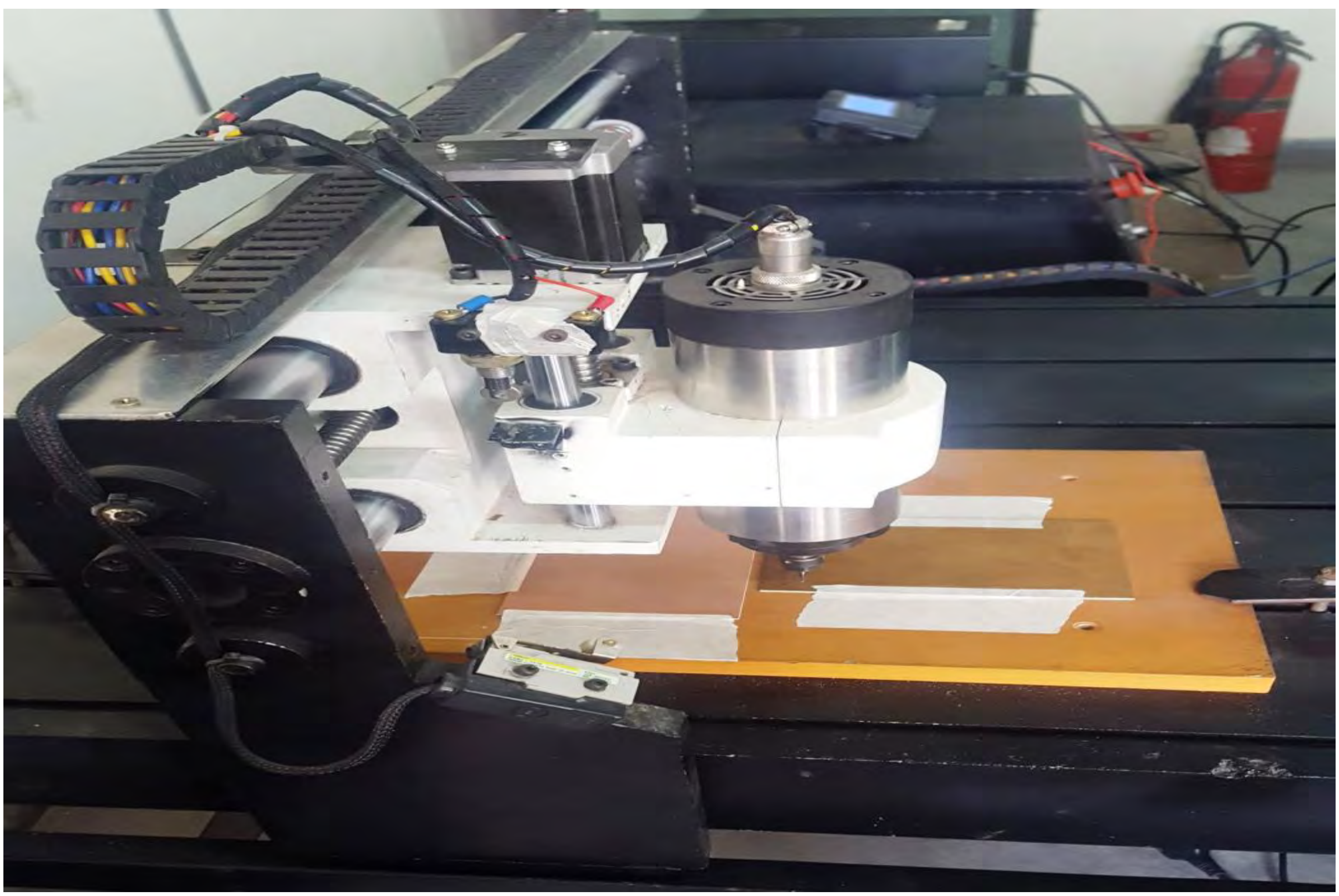

Figure 2.4: A CNC machine.

2.3.1 CNC machines working system

The CNC machine comprises of the computer in which the program is fed for cutting of the metal of the job as per the requirements. All the cutting processes that are to be carried out and all the final dimensions are fed into the computer via the program. The computer thus knows what exactly is to be done and carries out all the cutting processes. CNC machine works like the Robot, which has to be fed with the program and it follows all your instructions.

2.3.2 Types of CNC Machines

CNC machines typically fall into one the two general categories

1. conventional machining technologies and
2. novel machining technology:

Conventional Technologies:

Drills: Drills work by spinning a drill bit and moving the bit about and into contact with a stationary block of stock material.

Lathes: Lathes, very much the inverse of drills, spin the block of material against the drill bit . Lathes typically make contact with the material by laterally moving a cutting tool until it progressively touches the spinning material.

Milling Machines:

Milling machines are probably the most common CNC machine in use today. They involve the use of rotary cutting tools to remove material from the stock unit.

2.2.3 Novel Technologies

Electrical and/or Chemical Machining: There are a number of novel technologies that use specialized techniques to cut material. Examples include Electron Beam Machining, Electrochemical machining, Electrical Discharge Machining (EDM), Photochemical machining, and Ultrasonic machining. Most of these technologies are highly specialized and are used in special cases for mass-production involving a particular type of material.

Other Cutting Mediums: There are a number of other novel technologies that use different mediums to cut material. Examples include laser cutting machines, oxy-fuel cutting machines, plasma cutting machines, and water-jet cutting technology.

2.2.4 Materials Used

Almost any material can be used in a CNC machine. It really depends on the application. Common materials include metals such as aluminum, brass, copper, steel, and titanium, as well as wood, foam, fiberglass, and plastics such as polypropylene.

2.3 About 3D Printing

3D design, printing and fabrication is one of the hottest new trends for Makers, and rapidly becoming easily accessible to everyday tinkerers like you! Whether you're looking to do some serious design or prototyping, or you're simply excited to play with the new technology, the Shed has a machine that meets your needs.

It all starts with the creation of a 3D model in your computer. This digital design is for instance a CAD (Computer Aided Design) file. A 3D model is either created from the ground up with 3D modeling software or based on data generated with a 3D scanner. With a 3D scanner you’re able to create a digital copy of an object.

2.3.1 Software for 3D

The software job is to convert a 3D model designed by a CAD tool to movement and printing orders. It is built, from scratch, using C# and an object oriented structure is followed for good organization.

Following conventions which are generally used in computer aided manufacturing (CAM), to-be-printed 3D models are assumed to be in STL format and movement and printing orders are generated as G-codes and M-codes. A model in STL format is represented by typically a huge number of triangular facets that are connected together to form a mesh that describes the outer surface of the object. G-codes and M-codes, on the other hand, are standardized codes to communicate with and control CAM machines. They are typically executed one by one until the final product is reached.

2.3.2 Firmware and electronics interface

The firmware and electronics interface included primarily an Arduino microcontroller that digitally controls the electrical and mechanical components, and executes G-codes received from the software. To have a robust circuit design implementation, the electronics and microcontroller are mounted on a specially-designed PCBs. To be able to run high-torque loads (in case of a friction problem), special drivers that can handle high current are used. Also, the Arduino controls the printing temperature applying tuned PID algorithm.

2.3.3 Hardware

Finally, the hardware guarantees accurate and balanced movements along the 3 dimensions using stepper motors (mechanical constraints). Due to the complexity and cost of starting from scratch in this part, the hardware is based on a body of an old CNC machine. After introducing several modifications to convert the old body to a 3D printer, the final design achieves a high level of accuracy and precision.

2.4 Application for Rapid Prototyping

CNC machines were the first major break-through in the field of rapid-prototyping. Before numerical control (in the case of punched tape technology) and computer numerical control (with analog and digital computing), parts had to be machined by hand. This invariably led to larger margins of error in end prototype products and even more so when machines were manually used for larger scale manufacturing.

2.5 Comparison between CNC and 3D Printing

The honest truth is that it depends - on the material, the complexity of the part, and the economic factors at play. 3D printing technology like FDM machines build parts from the bottom-up. They can create complex shapes and internal components somewhat more easily than a CNC machine. By contrast, conventional CNC machines are somewhat limited by the tools available and the axes of rotation the machine is capable of utilizing. On the flip side, FDM prototyping is much more limited by materials than is a machined block of material. For example, if you need a prototype of a living hinge you would want to use CNC and polypropylene. Anything can be machined while by contrast only certain materials have been adapted into filaments suitable for 3D print.

Application for Manufacturing: Many novel CNC specialty machines are built specifically for niche manufacturing processes. For example, electrochemical machining is used to cut highly durable metal products not otherwise feasible. Conventional CNC machines are more adept at and typically used for prototype development than manufacturing.

Chapter 3

Design and Implementation of the Edukit using 3D Printing Technology

3.1 Introduction

Rapid prototyping is very much essential for an electronic product since the world market is very competitive. If a product is developed but it is not brought in the market the whole R & D effort might be lost due to heavy competition in the market. This chapter presents the design and implementation of an Edukit as a case study and shows how it can be developed rapidly using 3D printing technology. Necessary hardware and software used in this project also been described.

3.2 Requirement Gathering, Specification and Planning

Requirement Gathering, specification and planning are essential parts of any project management. During the process, different similar software and hardware are analyzed to design the EDUKIT. The software and hardware requirements are also studied and specified in this phase. Different types of idea about the development are written up. Next is the planning phase, a plan is made to develop this circuit with requirement document.

Here are two part of project to implementation this project

1. PCB design by CNC machine
2. Casing design by 3D printing for EduKit

3.3 PCB design by CNC machine

Planning of PCB design by CNC machine, its carry some step of works .fistly we need to schematic design by eagle software and convert schematic to layer design. After layout design we can know it's one layer pcb bord or double layer pcb. After that we are generate g-code for CNC machine. Finally we can printing a pcb board by CNC machine. Figure3.1 shows the flow chat of PCB design by CNC machine.

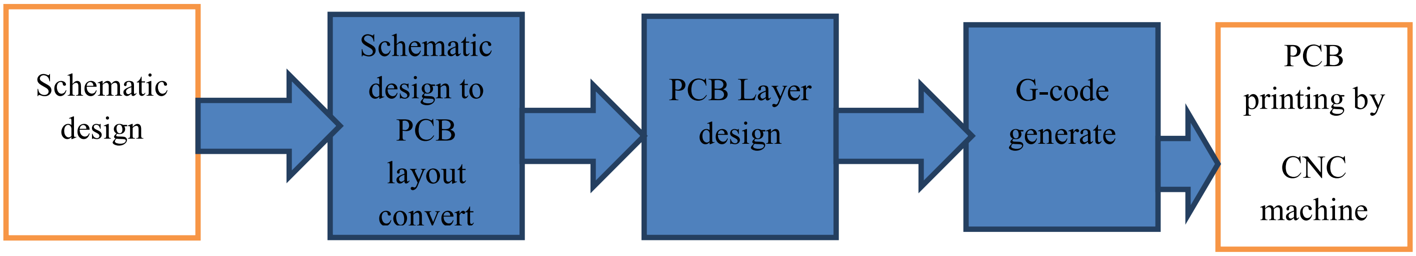

Figure 3.1: Flowchart of a PCB design by CNC machine.

3.4 Casing design by 3D printing

For any kind of object of 3D print we need to do some steps of works. firstly we need to design of the object as a 3D model by any kind of 3D software like fusion 360 degree. Then we are generate G-code from the 3D model file . after that we are configure our 3D printer then we can run our G-code to 3D printers and we will get out desert output from printers. Figure 3.2 shows the flowchart of 3D design printing.

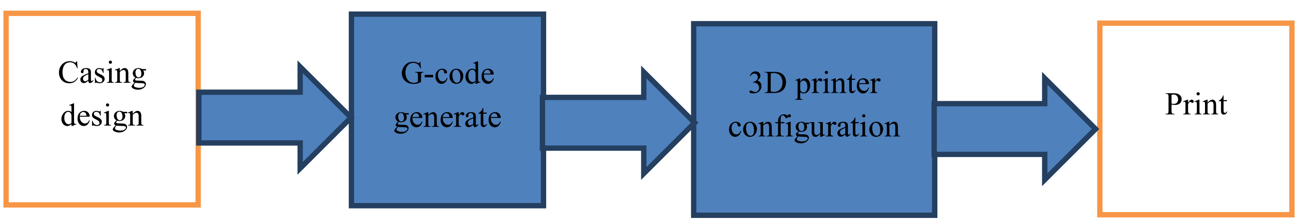

Figure 3.2 flowcharts for implementation of 3D printing.

3.5 Hardware Requirements list

This project require following hardware:

A. PCB Board
B. Spender
C. CNC machine
D. Tap
E. 3-D printer

F. Laptop
G. Copper wipe
H. Glue stick
I. 1.75mm PLA 3D filament

3.6 Software Requirements list

This project require following software:

A. EAGLE 7.5.0 version software
B. Copper CAM software
C. Pronterface
D. Adtodesk Fusion 360
E. Cure 15.04.5

3.7 Schematic design by EAGLE platform

For schematic design I need to install EAGLE 7.5.0 version software. Figure 3.3 shows the EAGLE 7.5.0 version software outlook. And figure 3.4 shows the schematic design platform on EAGLE 7.5.0 version.

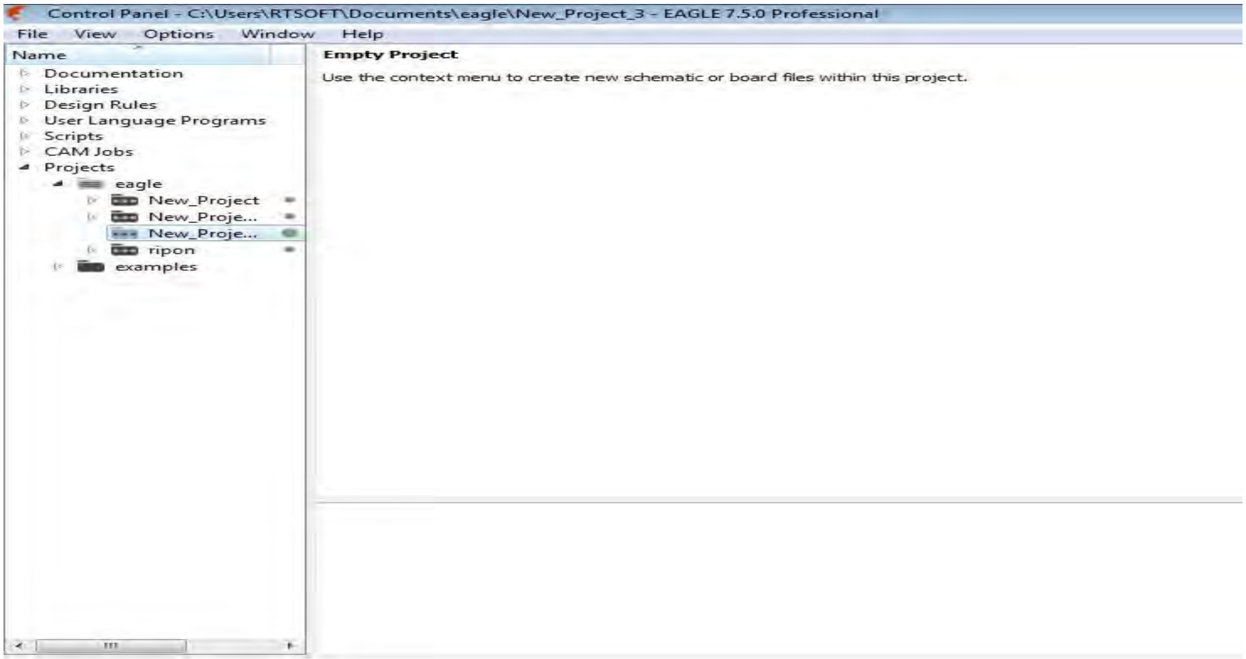

Figure 3.3: EAGLE 7.5.0 software layout

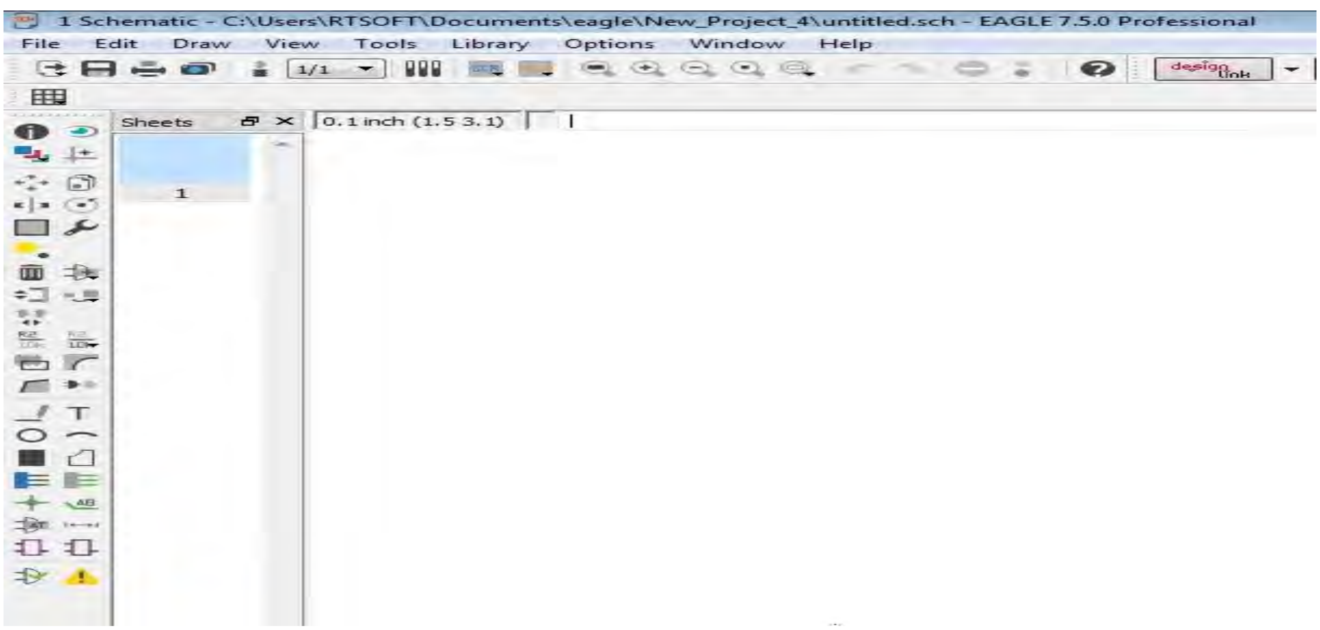

Figure 3.4: The schematic design platform on EAGLE 7.5.0 version.

3.8 Schematic Design with Eagle PCB Design Tool

Using eagle software we are adding various components. for add component we nned to click on add bottom and writing on search box which component we want .when we find my one object then we press on Ese and find same window for component .here we are fine all component name, description and attributes of component. Figure 3.5 shows the how to add component and where the add button on eagle software.

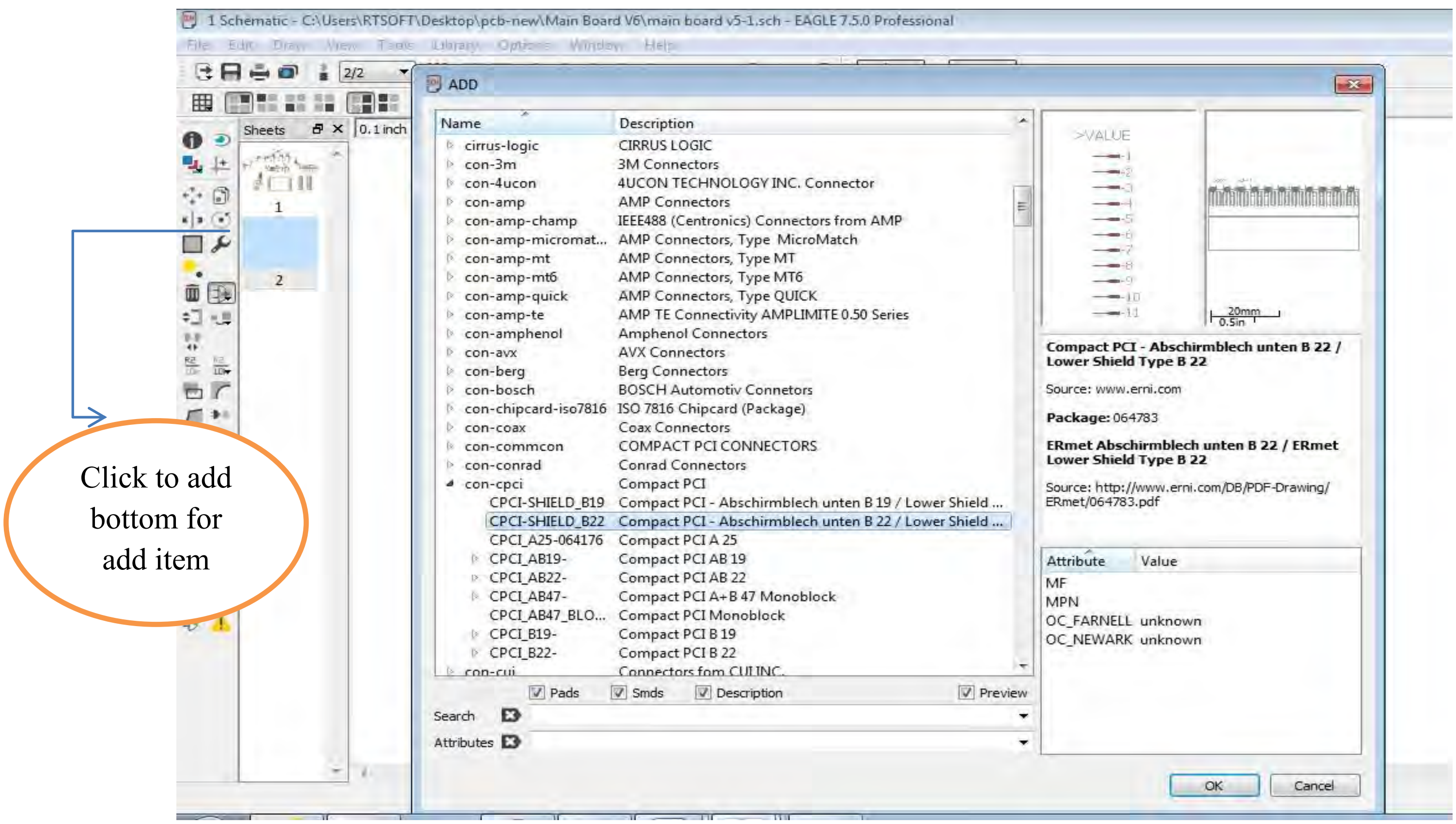

Figure 3.5: Add bottom and component list window on eagle software.

3.9 Schematic design

After added all component on schematic sheets we need to build connection with one component toanother and setup ground.

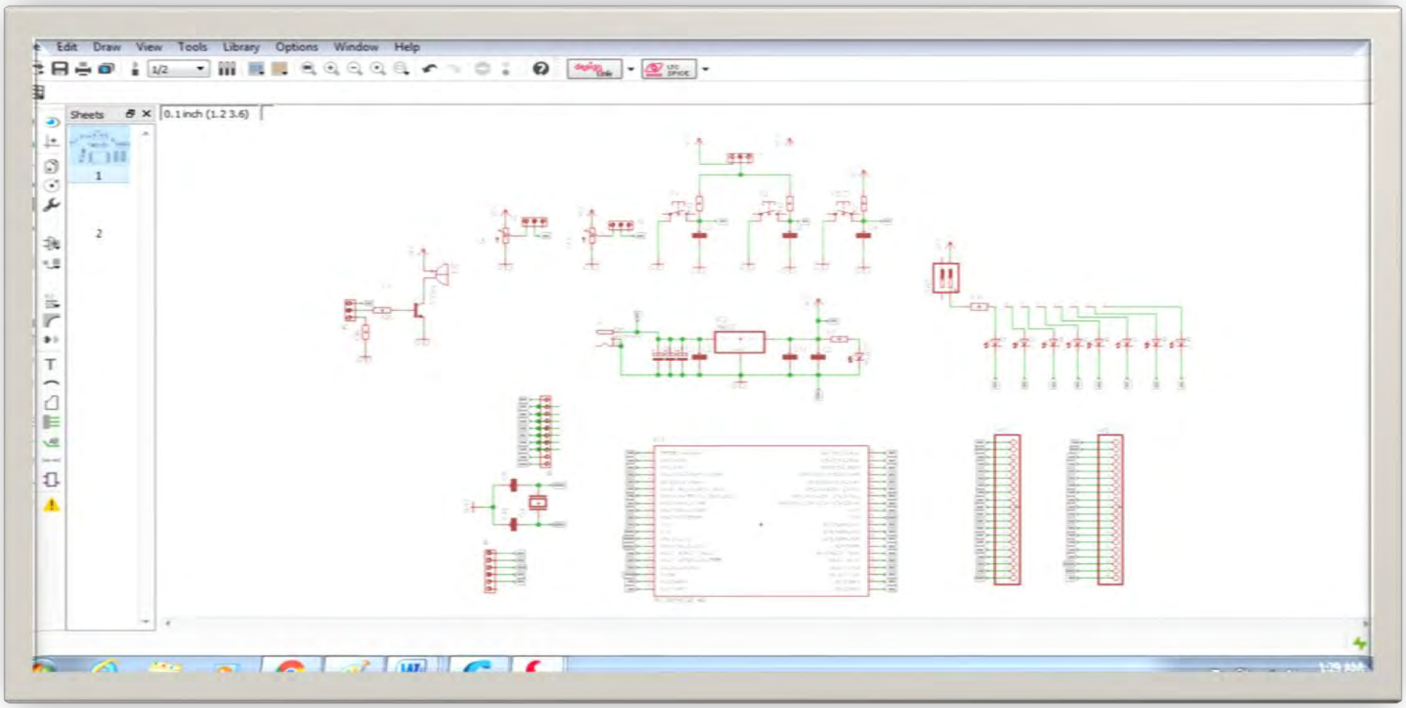

Figure 3.6 shows the Schematic design of our project.

3.10 generate of PCB board

After design of schematic we can convert schematic to pcb board. Figure 3.7 shows the converts tool of eagle software.

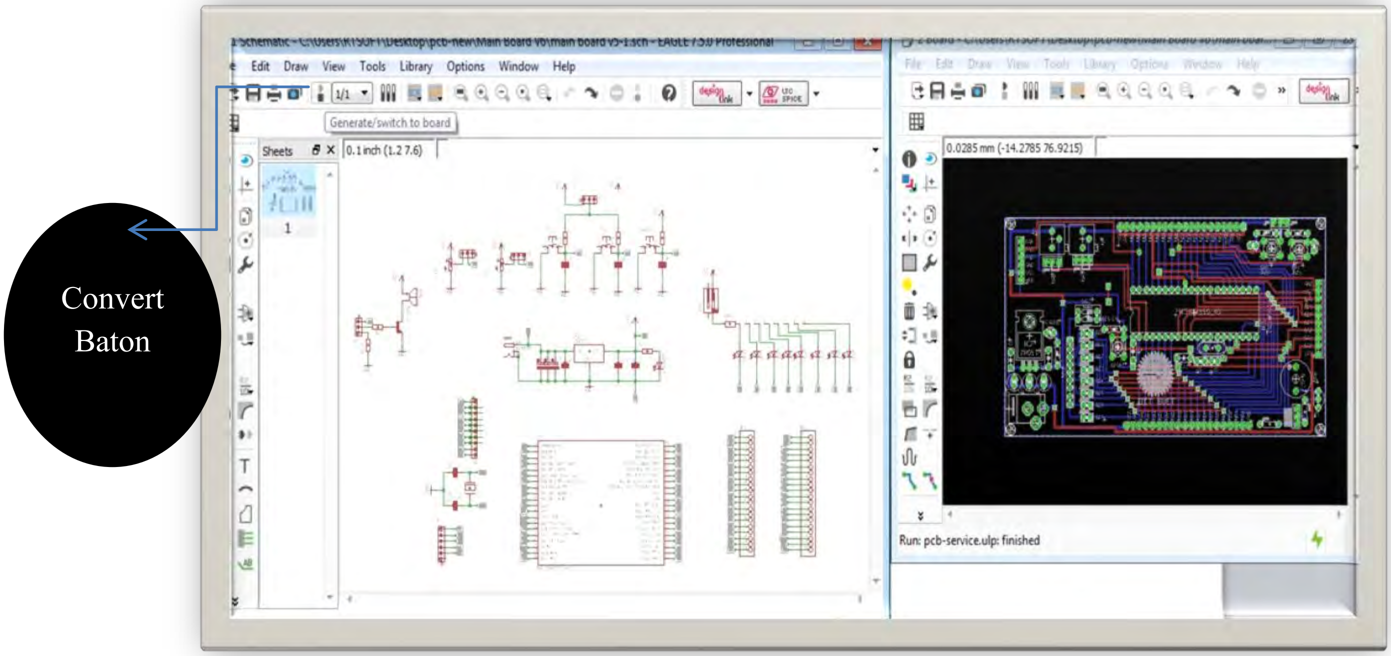

Figure 3.7: convert schematic to PCB board tool.

3.11 CopperCAM Software

For layer design & G-Code generate I need to install CopperCAM Software. Figure 3.8 shows the CopperCAM outlook.

Figure 3.8: CopperCAM Software outlook.

3.12G-code generate

I need to insert my Garber file to copperCAM software to design my top layer and bottom layer and set contours then mill, after that we will get G-code generate .Figure 3.9 shows the top layer of my CKT.

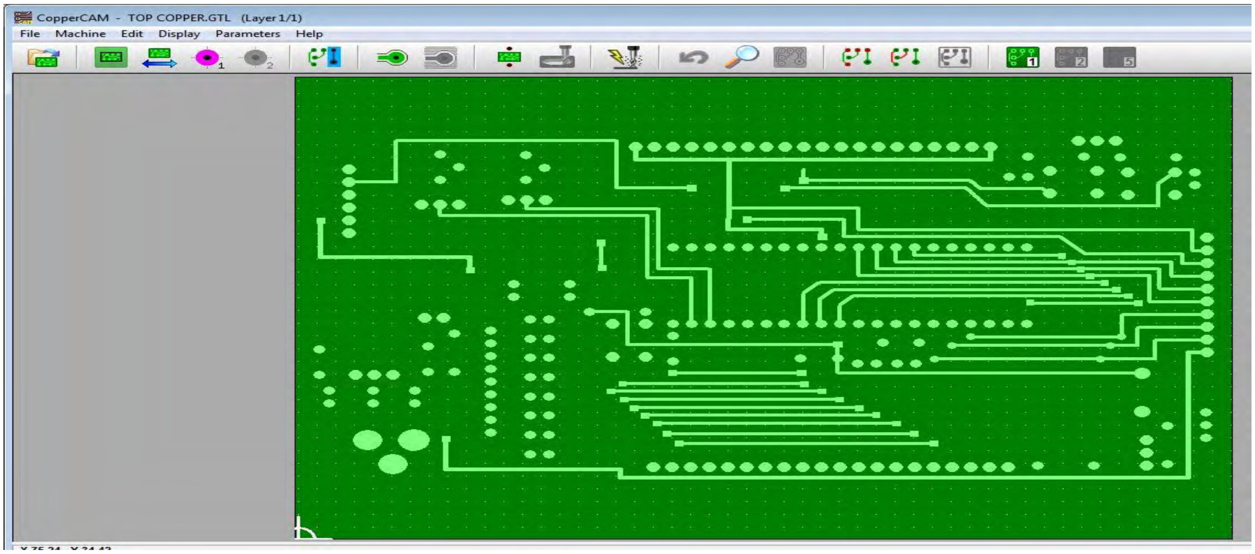

Figure 3.9: Top layer of my CKT.

3.13 PCB printing by CNC machine

When we will get G-code then finally we will printing my PCB by CNC machine , To operate the CnC machine we need to use Pronterface software.Figure 3.10 shows the PRONTEFACE software outlook.

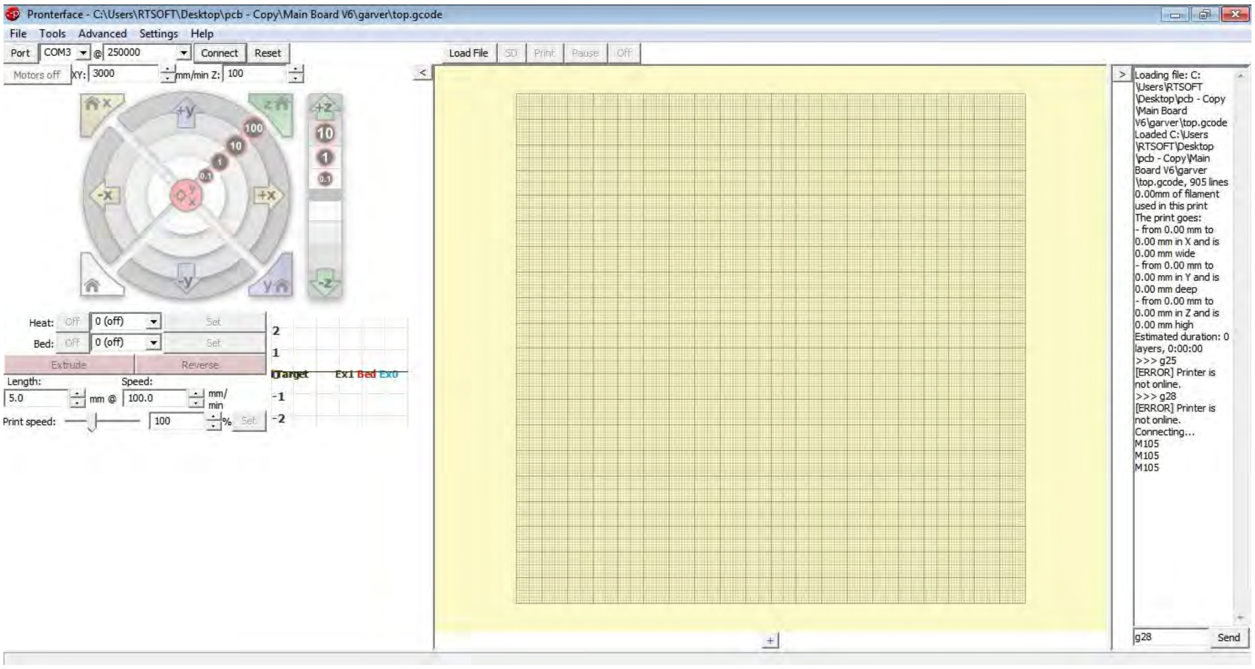

Figure 3.10: PRONTEFACE software outlook.

By PRONTEFACE software we will connect my laptop with CNC control section and select port, and then click to connect. After CNC connected to leptop we will set out PCB on CNC bad and load our G-Code file.

3.14 G-code

G-code is a programming language for CNC that instructs machines where and how to move. Most machines speak a different “dialect” of g-code, so the codes vary depending on type, make, and model. Each machine comes with an instruction manual that shows that particular machine’s code for a specific function.

G-code stands for “geometric code,” and follows some variation of the alpha numeric pattern:

N## G## X## Y## Z## F## S## T## M##

N: Line number
G: Motion
X: Horizontal position
Y: Vertical position
Z: Depth
F: Feed rate
S: Spindle speed
T: Tool selection
M: Miscellaneous functions
I and J: Incremental center of an arc
R: Radius of an arc

Alpha numeric codes are used for programming as they are a simple way to:

1. Define motion and function (G##)
2. Declare a position (X## Y## Z##)
3. Set a value (F## and/or S##)
4. Select an item (T##)
5. Switch something on and off (M##), such as coolant, spindles, indexing motion, axes locks, etc.

For example,

G01 X1 Y1 F20 T01 M03 S500

would generally indicate a linear feed move (G01) to the given XY position at feed rate of 20. It is using Tool 1, and the spindle speed is 500. Miscellaneous functions will vary from machine to machine, so in order to know what the m-code means, the machine’s instruction manual will need to be referenced.

3.13.1 Machine Motion

Everything a machine can do is based on three basic types of motion:

1. Rapid move: a linear move to an XYZ position as fast as possible
2. Feed move: a linear move to an XYZ position at a defined feed rate
3. Circular move: a circular move at a defined feed rate

Every g-code tells the machine which variation of these basic motions to perform, and how to perform it.

X and Y are Cartesian coordinates for horizontal and vertical position, and Z represents the depth of the machine. These alpha numerals will follow the motion/function command (G) to declare the position of the machine.

Next, F determines the feed rate (for feed moves or circular moves), while S determines the spindle speed. T is used to select a tool. Other alpha numerals used in programming might include I, J, and R, which have to do with arc centers and radii.

3.13.2 Miscellaneous Codes

The line of a program might also include m-codes, which are generally codes that tell a machine how to perform an action. While not guaranteed to be the same across machines, some common, standard m-codes are:

- M00: Program stop
- M01: Optional program stop
- M02: End of program
- M03: Spindle on clockwise
- M04: Spindle on counterclockwise
- M05: Spindle stop
- M06: Tool change
- M08: Flood coolant on
- M09: Flood coolant off

- M30: End of program/return to start
- M41: Spindle low gear range
- M42: Spindle high gear range

Chapter 4

Result and discussion

4.1 Introduction

This chapter represents the soft design of the circuit, prototype of the EduKit PCB using the various software and CNC machine also 3D printing of BOX and Lid.

4.2 Schematic design of project CKT

The schematic has been designed at Eagle 7.5.0 crack version software and the snapshot of the expected schematic layout has been taken. Figure 4.1 shows the schematic design of the ckt.

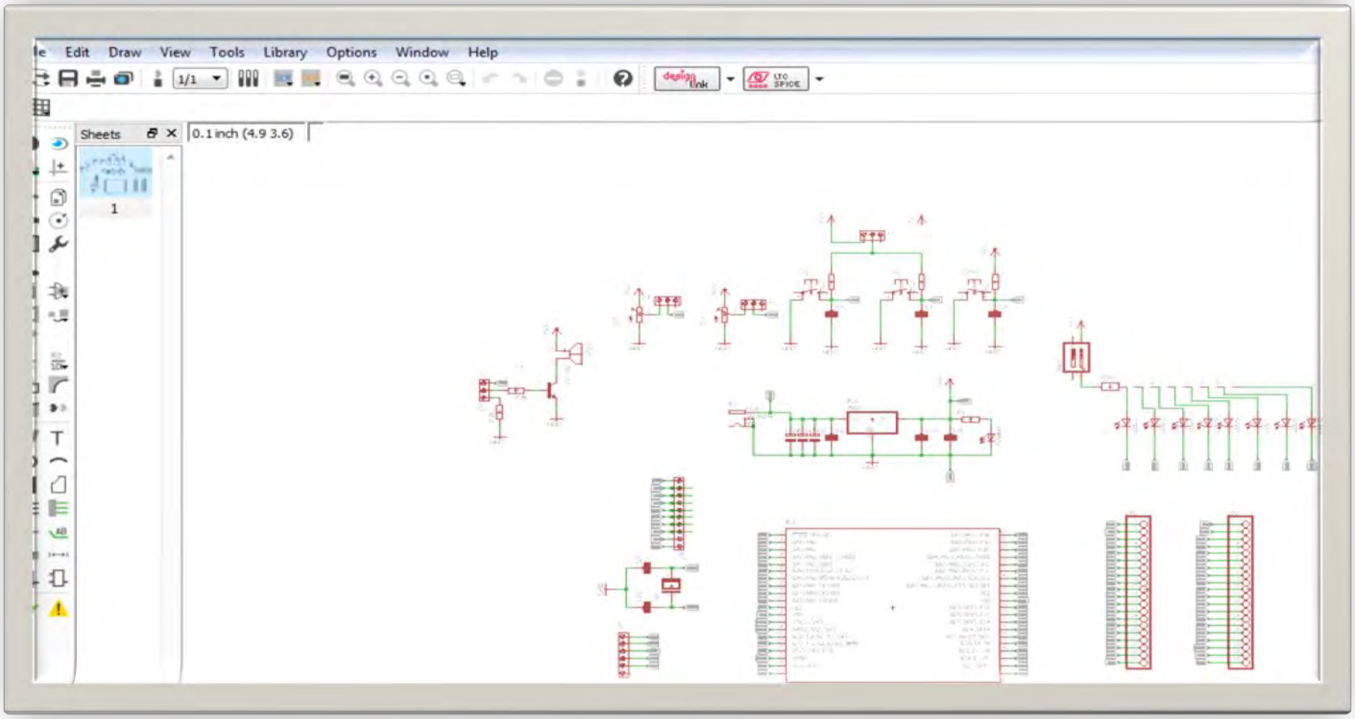

Figure 4.1: CKT schematic design.

4.2.1 The schematic has been converted by Eagle 7.5.0 crack version software to PCB board and the snapshot of the expected PCB layout has been takenwhich showing byFigure4.2 and 4.3 .

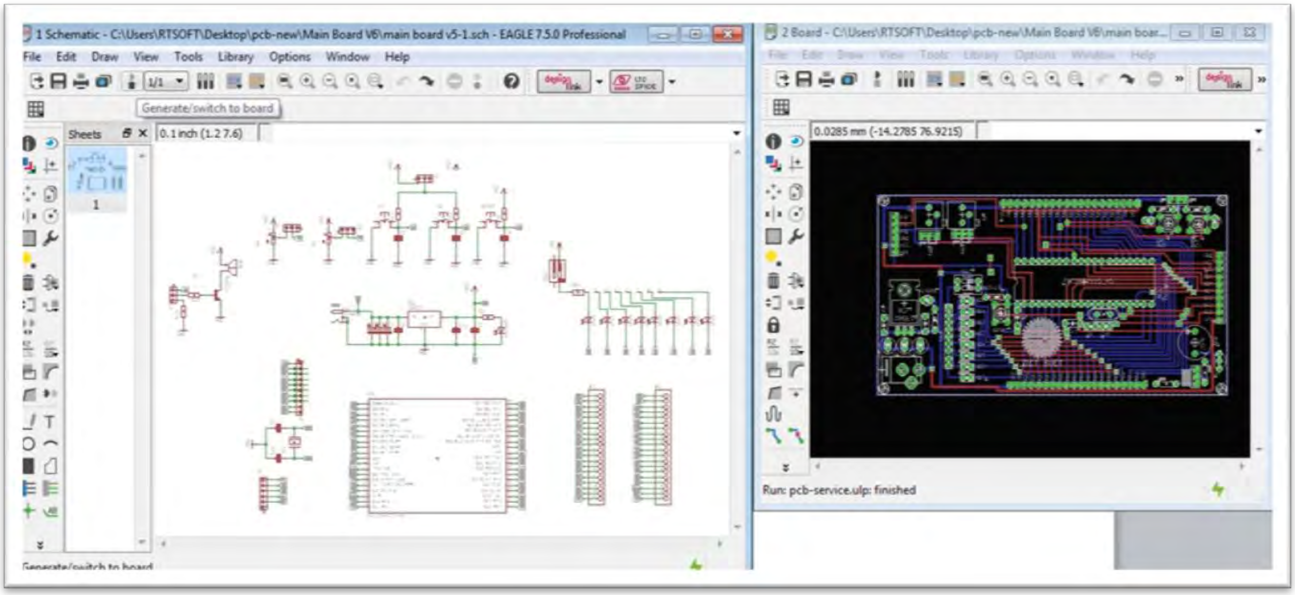

Figure 4.2: Converted schematic design to PCB Board.

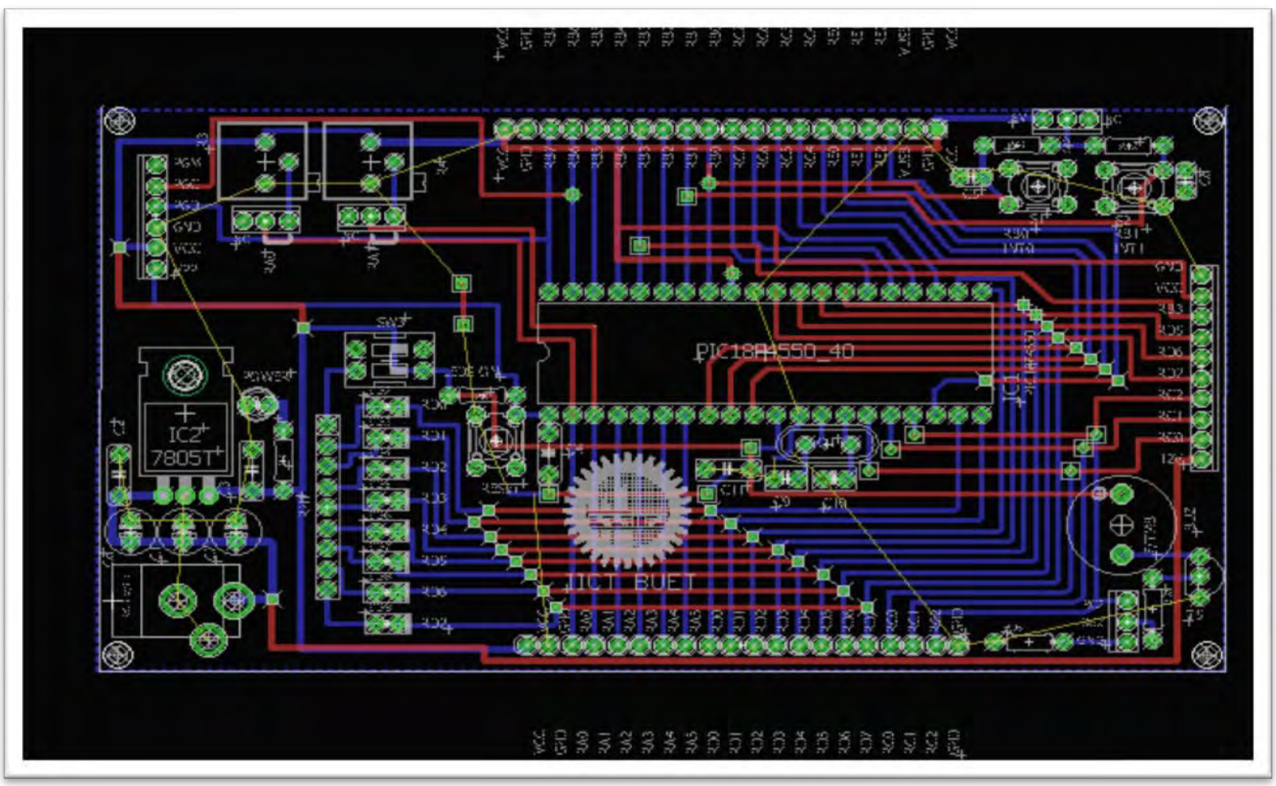

Figure 4.3: Generated PCB Board

4.3 Fabricate PCB using copperCAM Software

The PCB has been Fabricate at CopperCAM crack version software and the snapshot of the expected PCB layout has been taken. Figure 4.4 and 4.5 shows the schematic design of the ckt.

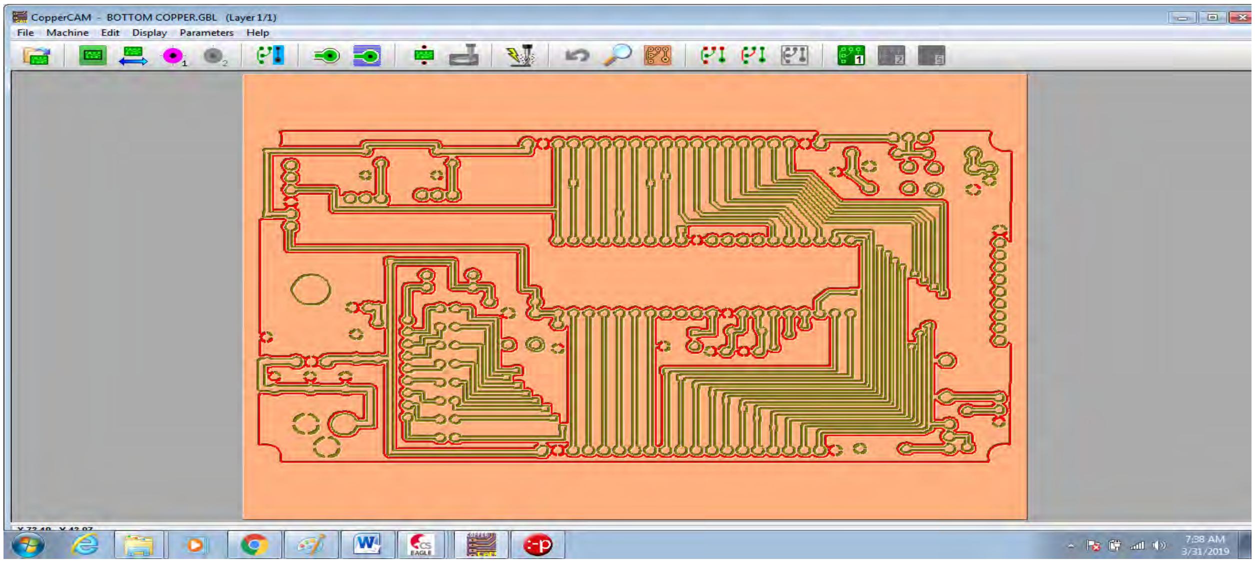

Figure 4.4: Fabrication of PCBBoard (Bottom Layer)

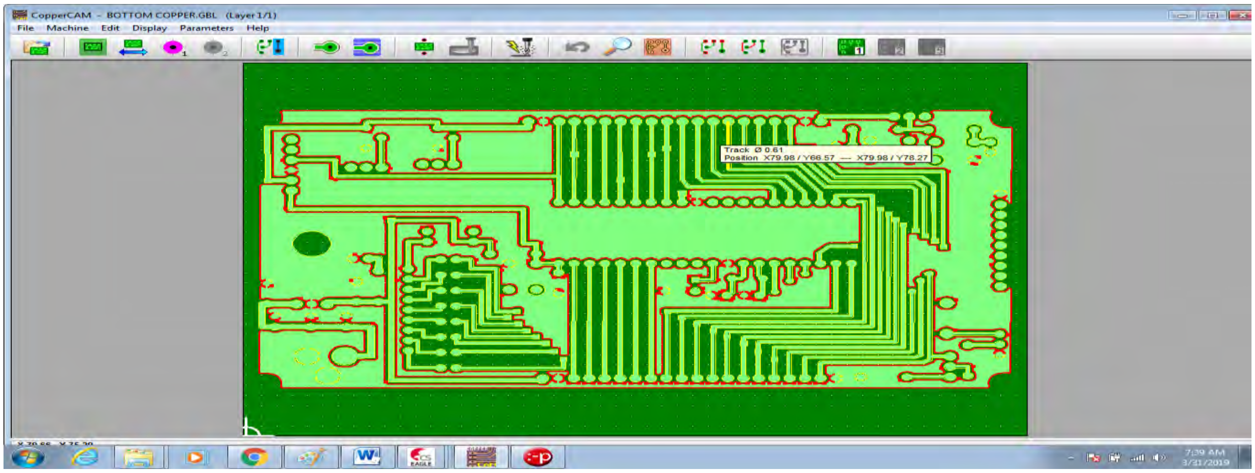

Figure 4.5: Fabrication of PCB Board (Bottom Layer)

4.4Resulting G-code

4.5 CNC milling machine and its operation

The CNC milling machine operates by Printrunsoftware and the snapshot of the Printrun software.Figure 4.6 Show the operational software for CNC machine. And figure 4.7 shows the cnc machine and CNC machine bad.

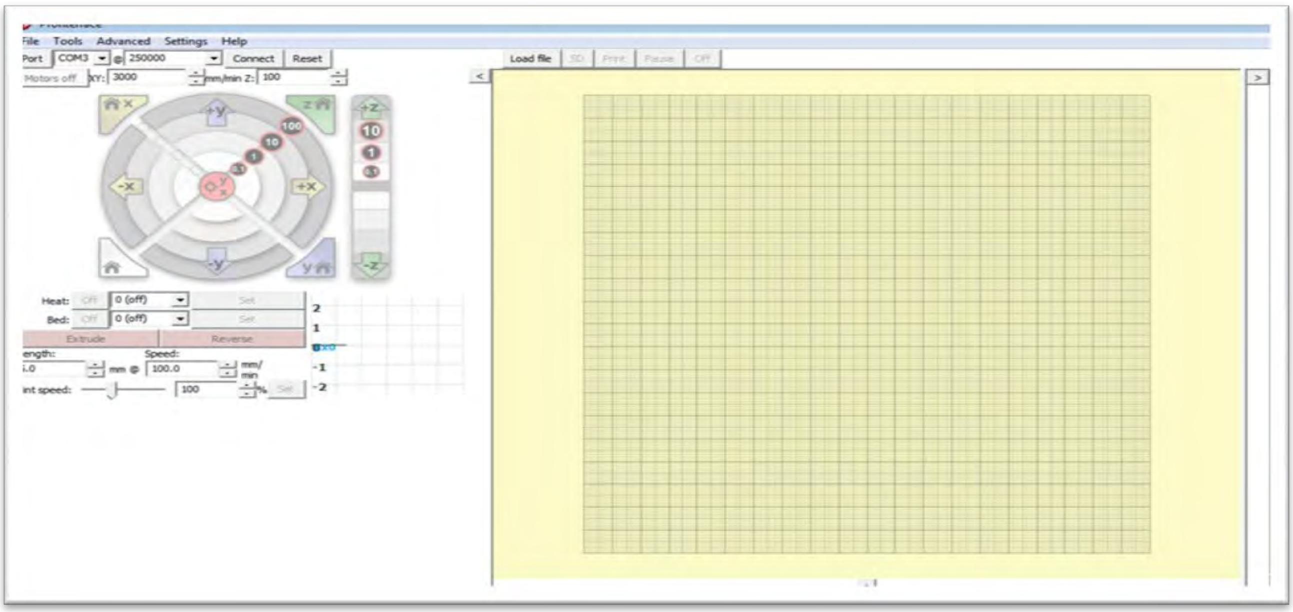

Figure 4.6: Printrun software outlook.

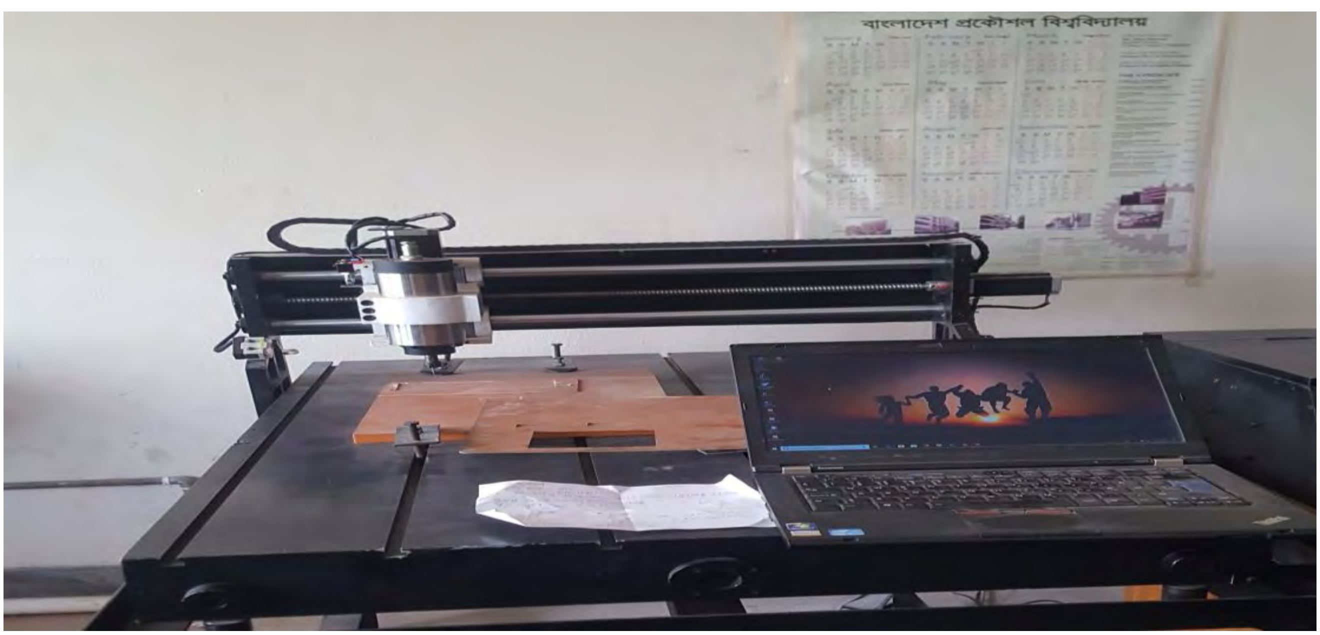

Figure 4.7: CNC milling machine bed.

4.6 Works on CNC milling machine

Design a PCB we need to set a PCB board on CNC bed. I am set a pcb board on CNC bed.Figure 4.8 Show the setup PCB board on CNC machine.

Figure 4.8: setup PCB board on CNC machine

4.7CNC Spindle and Motor check

Before cutting PCB I need to test and check motor speed and spindle of CNC machine. Figure 4.9 Show the setup spindle and motor speed of CNC machine.

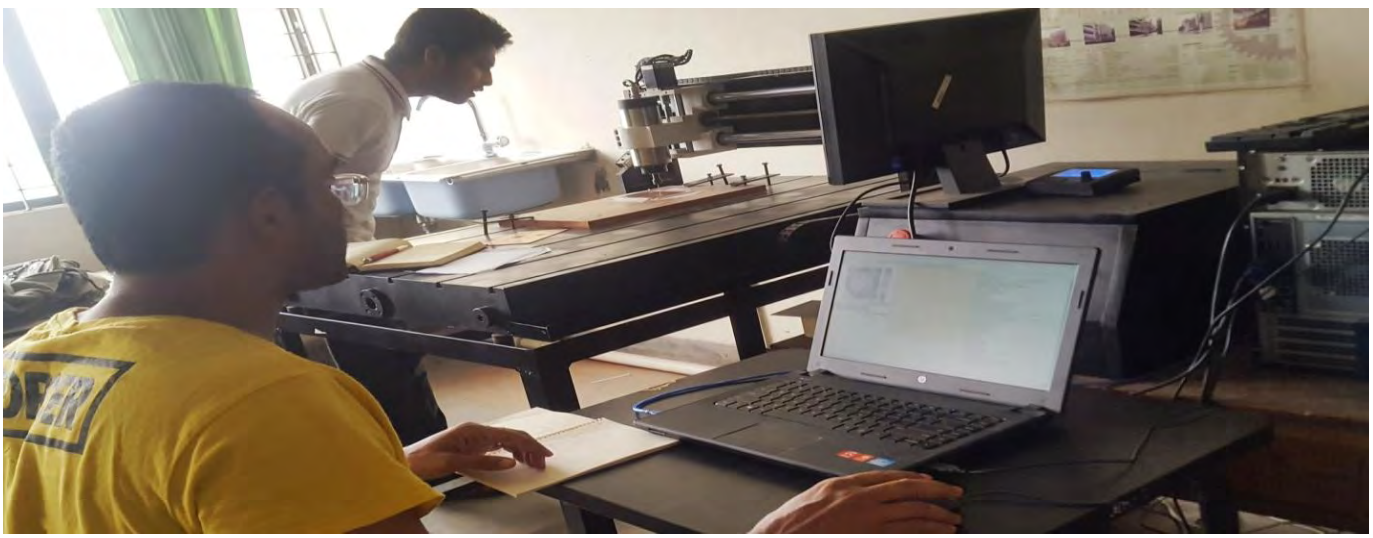

Figure 4.9: Checking CNC motor speed and spindle

4.8 PCB Cutting

After check motor and spindle we can run G-code for cutting PCB board.Figure 4.10 and 4.11 Show the drilling/Cutting a PCB board by CNC machine.

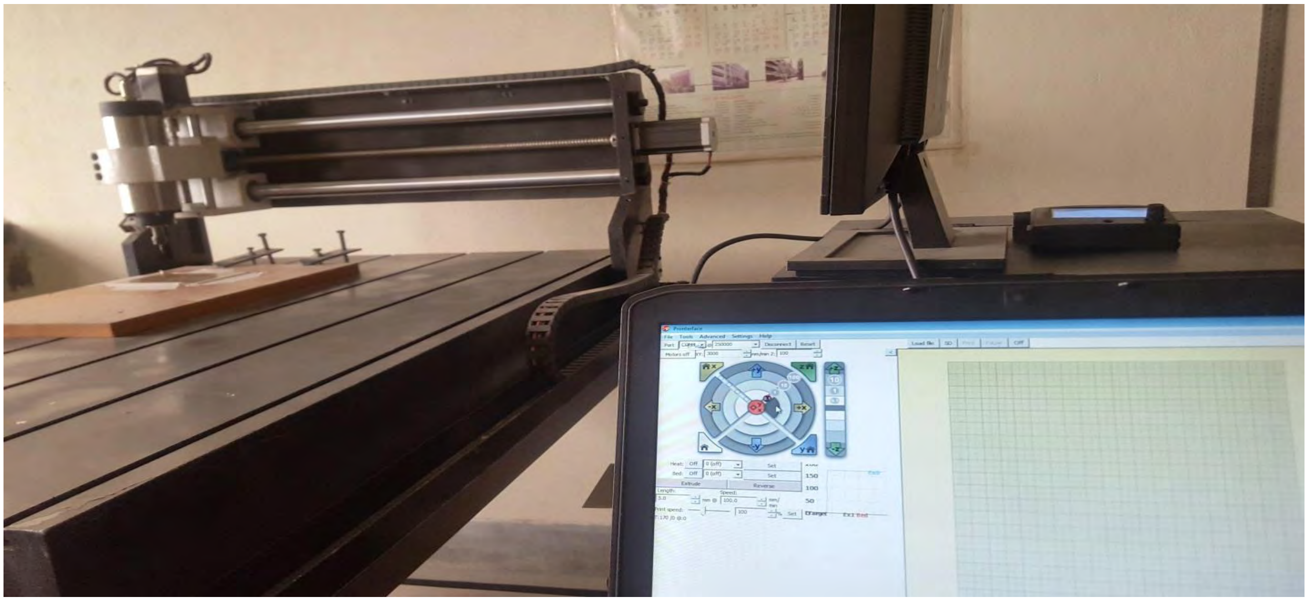

Figure 4.10: Operational of CNC machine.

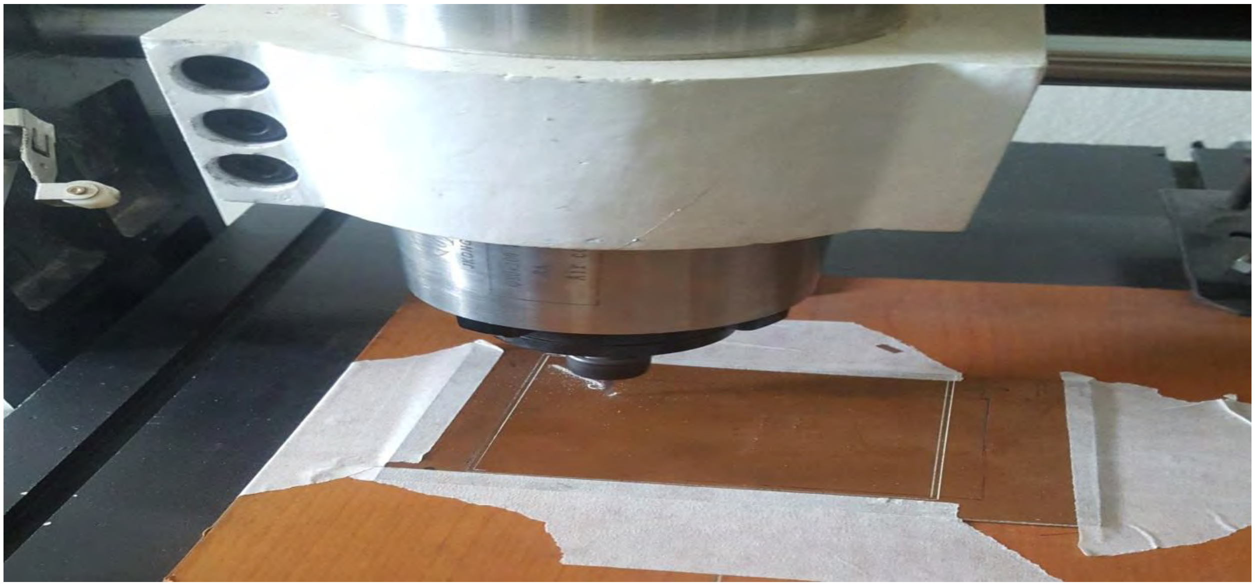

Figure 4.11: Drilling a PCB by CNC machine.

4.9 PCB Drilling

CNC machine starting drilling my PCB board and I was monitoring the driling. Figure 4.12 and 4.13 and 4.14Show the drilling/Cutting a PCB board by CNC machine and I monitor this.

Figure 4.12: Drilling of PCB by CNC machine.

Figure 4.13: Drilling monitoring of PCB by CNC machine.

Figure 4.14: Monitoring PCB milling on CNC machine

4.10 PCB Design output

Finally CNC machine drilling fine on my PCB board and I was get my PCB board. Figure 4.15 and 4.16 Show the output of the PCB.

Figure 4.15: End of the drilling

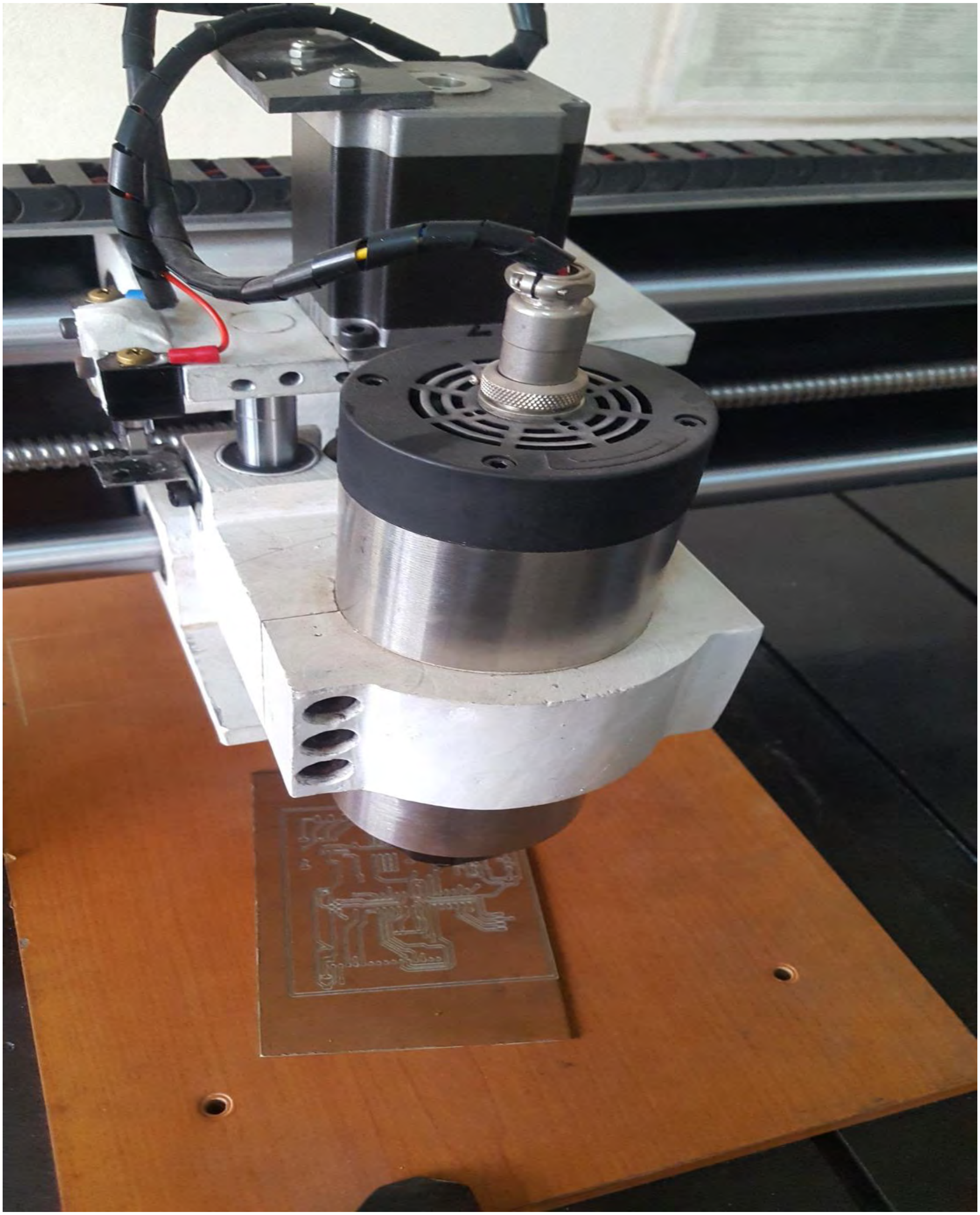

Figure4.16: Resulting PCB using CNC Milling Machine

4.11Casing design using 3D printer

Normally anyone can use any kind of software for 3D design but 360 fusion software are best for any 3D design .our project we use 360 fusion software for designing casing which is two parts

A. BOX
B. LID

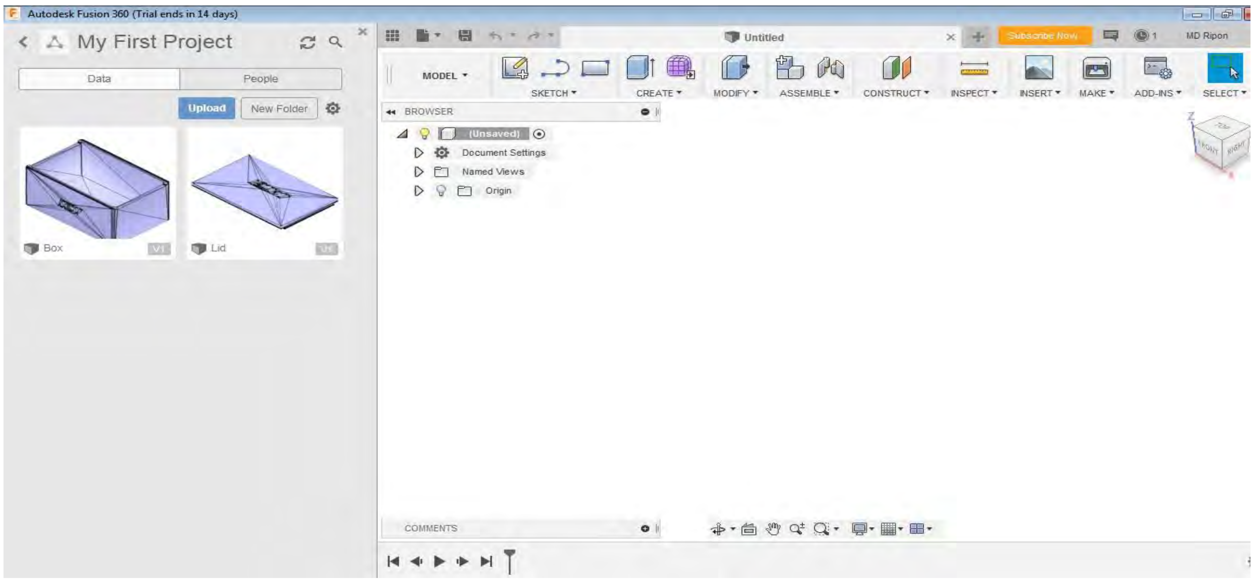

Figure 4.17: 360 fusion software outlooks

1. Box Design

   The Design a BOX by fashion 360 and the snapshot of the expected BOX layout has been taken. Figure 4.18 shows the BOX.

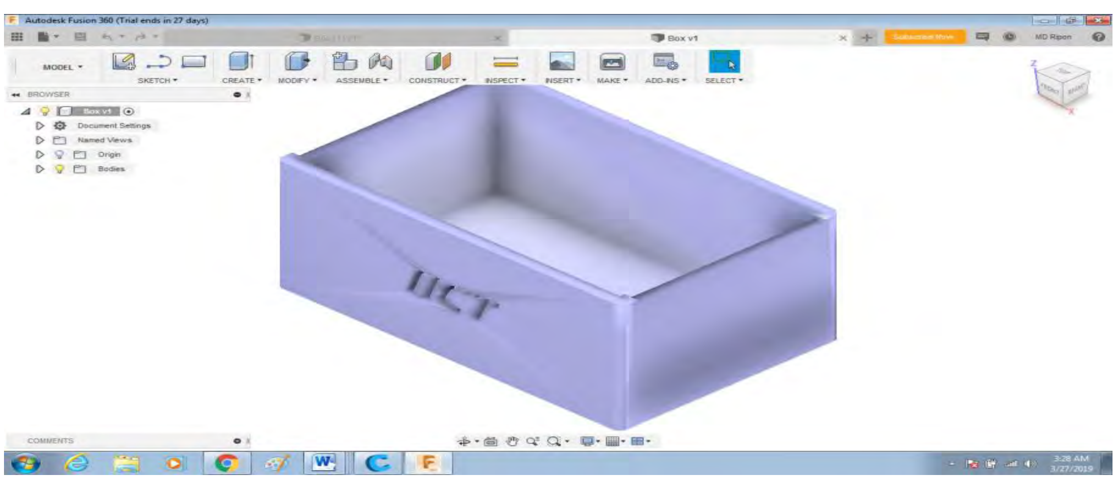

Figure 4.18: Layout of BOX

2. Lid design

The Design a LID by fashion 360 and the snapshot of the expected LID layout has been taken. Figure shows the lid and Figure4.19 shows the lid. After complete any design we need to save file **.stl** format

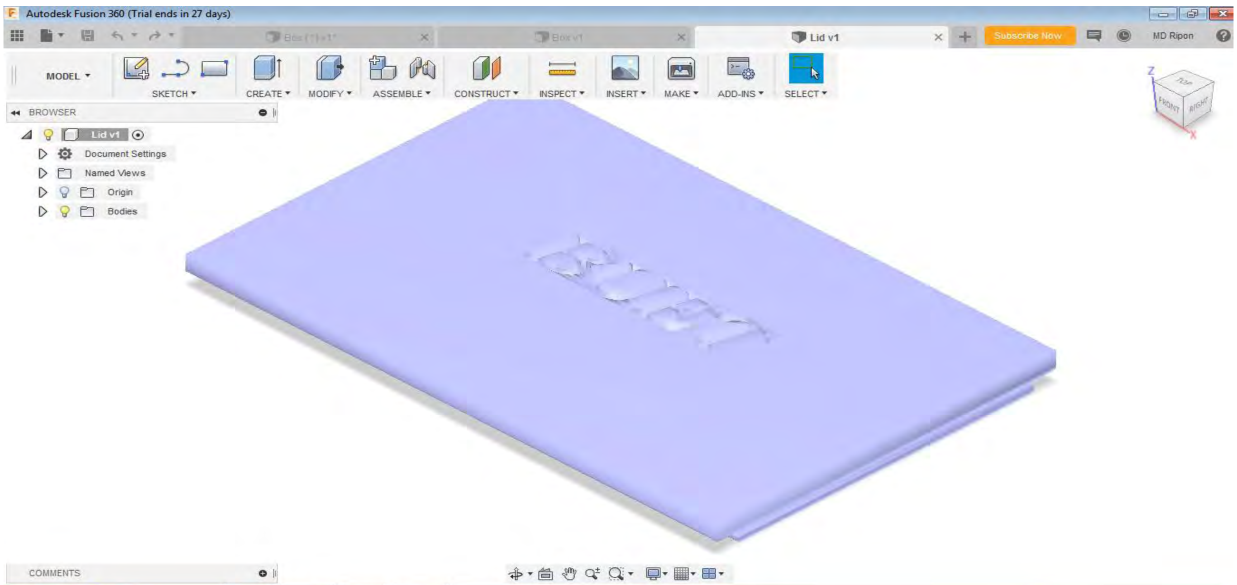

Figure 4.19: Layout of Lid

4.12 3D printer configurations

After complete 3D design I need to use CURA software for using 3D printer, all kind of 3D printer's settings and generate a Garber file by cure software.Cure Software basic layout taken and shows by figure 4.20.

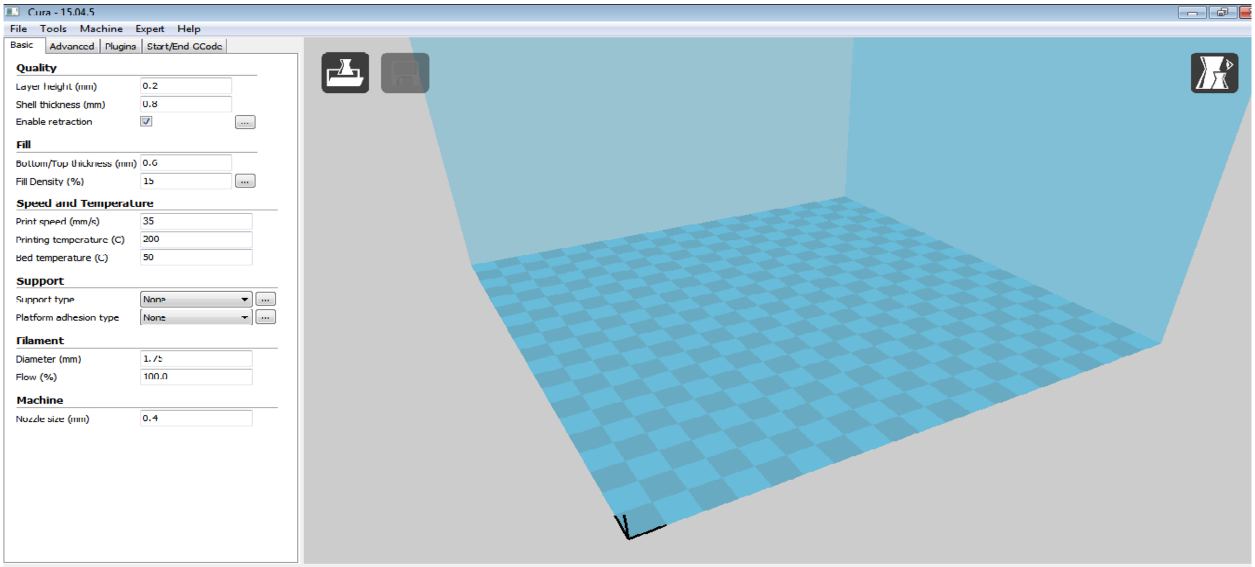

Figure4.20: CURE Software layout

4.13. The Basic configuration of 3D print

Printer configurations depend on printer model. We are using KARIKA 3D Printer. Let's show some basic issues setup for my printers:

X=200mm

Y=200mm

2=300mm

Nozzle=.4

Printing quality=0.15-0.2

Full density= 5mm-100mm

Speed =25-40mm/s ,30mm/s is the best

Temperature =120-210c , for good quality using 210c

Bad temperature=below 50c

Figure 4.21 and 4.22 shows the basic configuration of KARIKA 3D Printer.

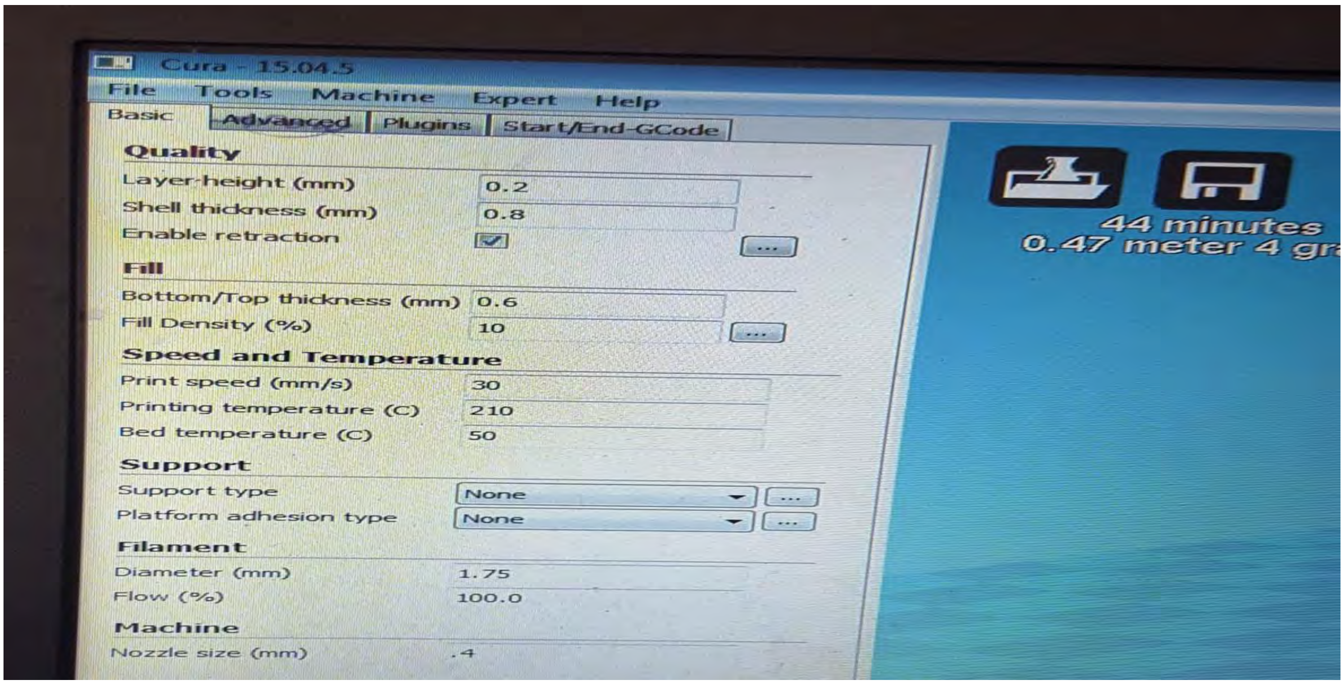

Figure 4.21: KARIKA 3D Printer configuration.

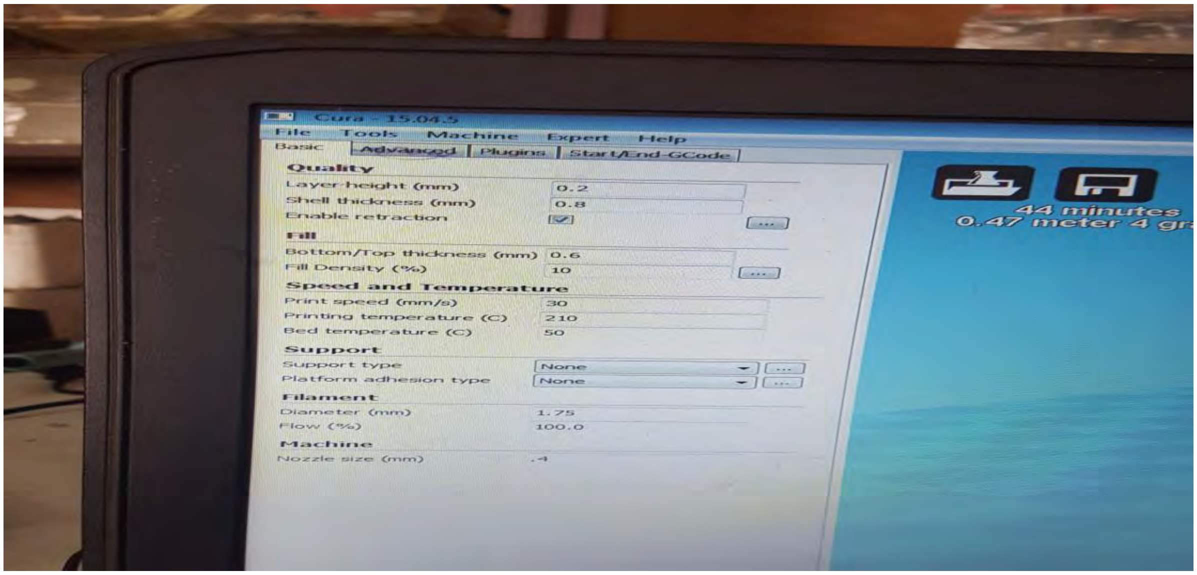

Figure 4.22: KARIKA 3D Printer configuration.

4.13.1 KARIKA 3D Printer Display

By printer display we can see the printing axis and percentage of the print. Figure 4.23 show the display of KARIKA 3D Printer Display.

Figure 4.23: KARIKA 3D Printer Display

4.13.2 Garber code generate

3D printer working by Garber code and its generate by cure software. setup all setting and upload object .stl format file and Firstly G-code generate .generated G code transfer by SD card to 3D printer Figure 4.24 shows the G-code generate platform

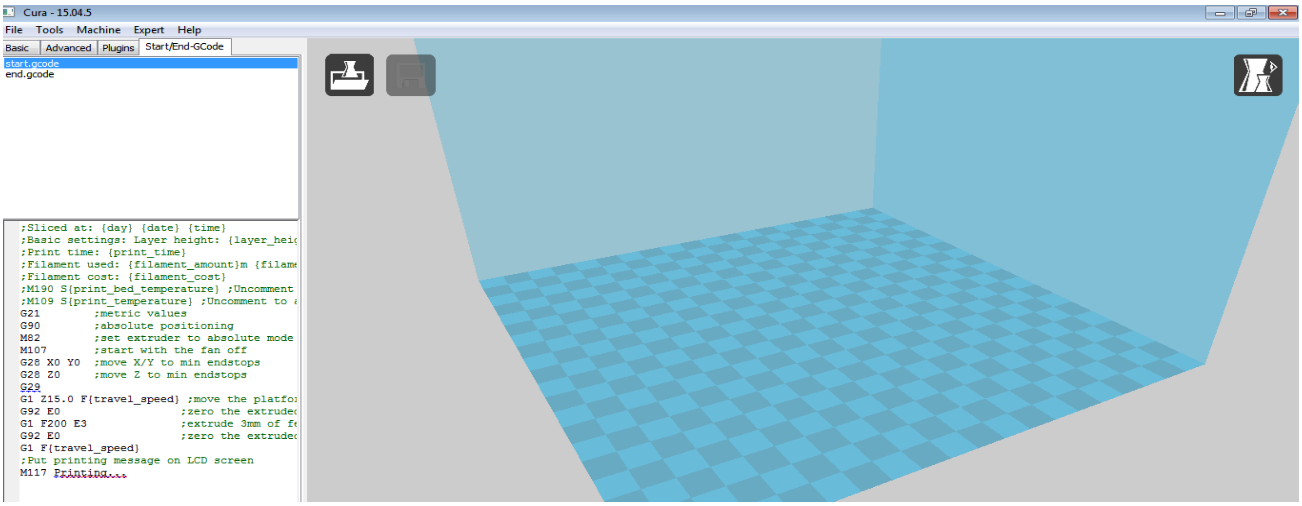

Figure 4.24: G-code generate platform

4.13.3 Object G- code generate

We are generating G-code for BOX and Lid and transfer G-code to 3D printer by SD card. Figure 4.25 shows Garber code generate for 3D printerfor BOX printing.

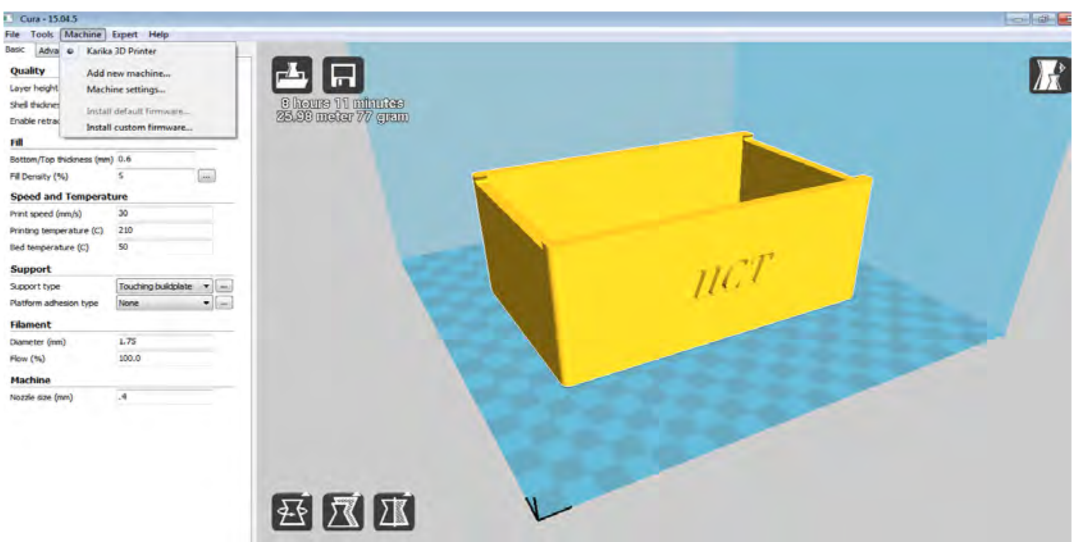

Figure 4.25: G- code generates for box print.

4.14 Object print

Inserts SD card to 3D printer slot then we turn on power of 3D printer and check printer condition by monitor of 3D printer .monitor have a bottom for change setting manually. Figure 4.26 shows the starting condition of lid.

Figure 4.26: BOX printing

Figure 4.27 shows the starting condition of printer .here monitor show time, temperatures, time and axis of printing.

Figure 4.27: Printer Display when BOX printing, its time 20minutes.

4.15 Some snapshot of BOX printing

Below Figure 4.28 to Figure 4.32 which show different condition of BOX printing by 3D printer.

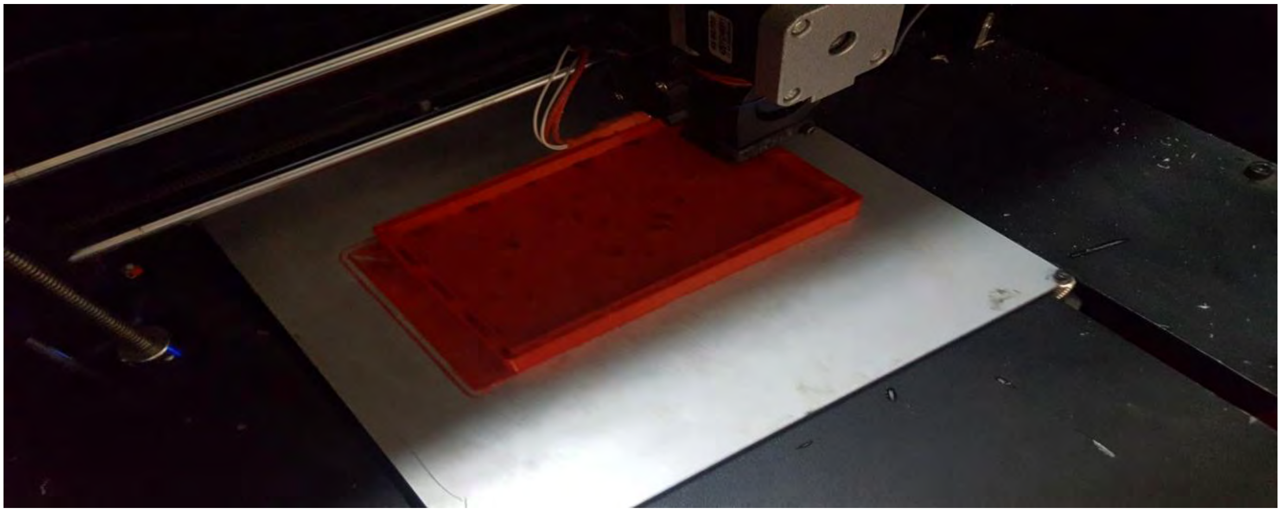

Figure 4.28: BOX Printing

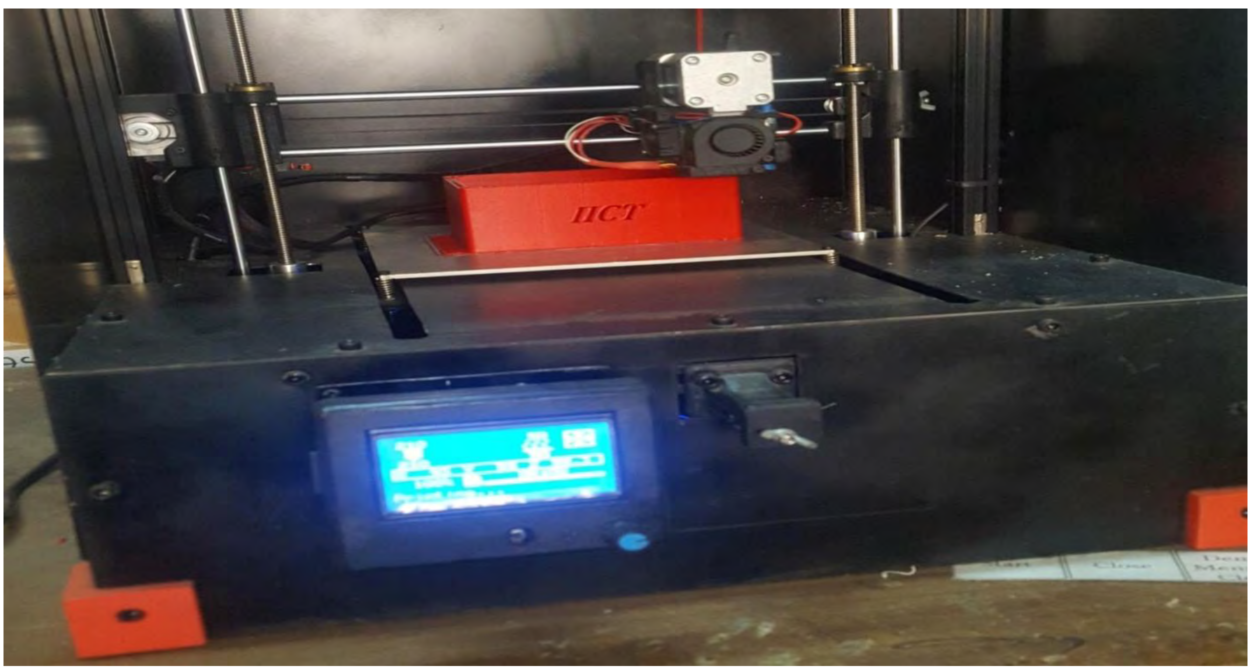

Figure 4.29: BOX Printing

Figure 4.30: BOX Printing

Figure 4.31: Printed BOX

Figure 4.32: Printed BOX

4.16 Lid printing

After complete Box printing I am cline 3D printer bed then checking all possible setting to start lid printing .from the SD card I was select lid G-code and start print. Below Figure 4.33 shows the configuration of 3D printer and Figure 4.34 to Figure 4.37 which show different condition of lid printing by 3D printer.

Figure 4.33: Re-configuration of 3D Printer

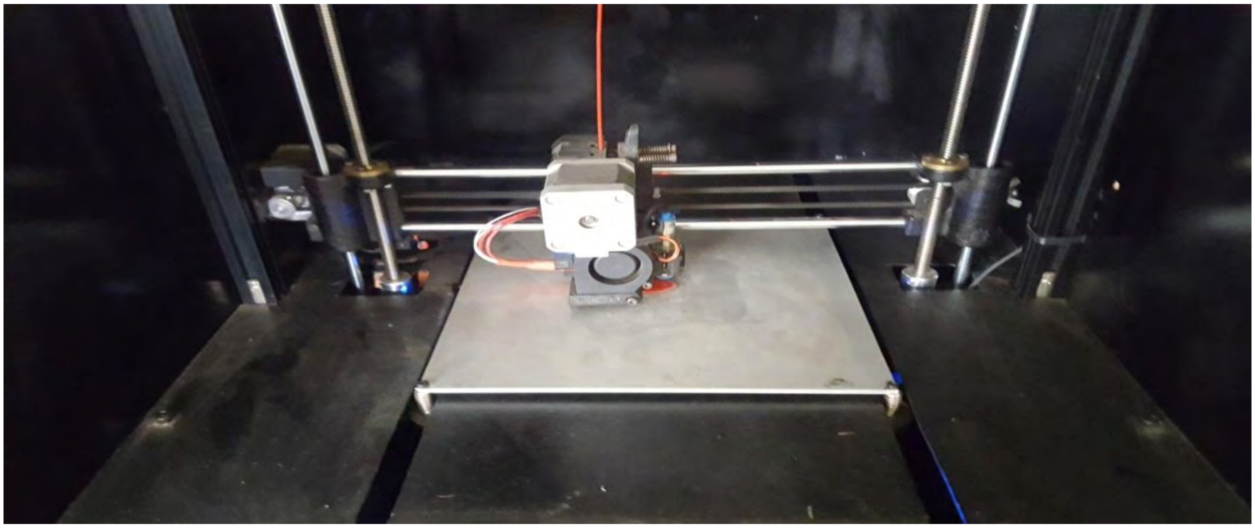

Figure 4.34: Lid printing

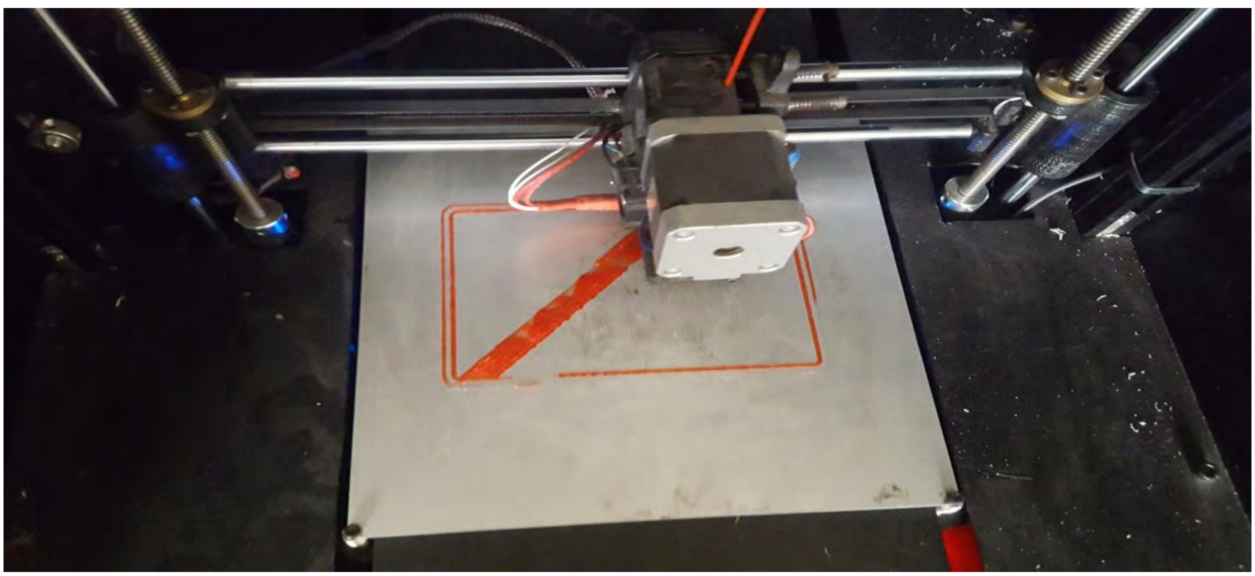

Figure 4.35: Lid printing

Figure 4.36: Lid printing monitoring.

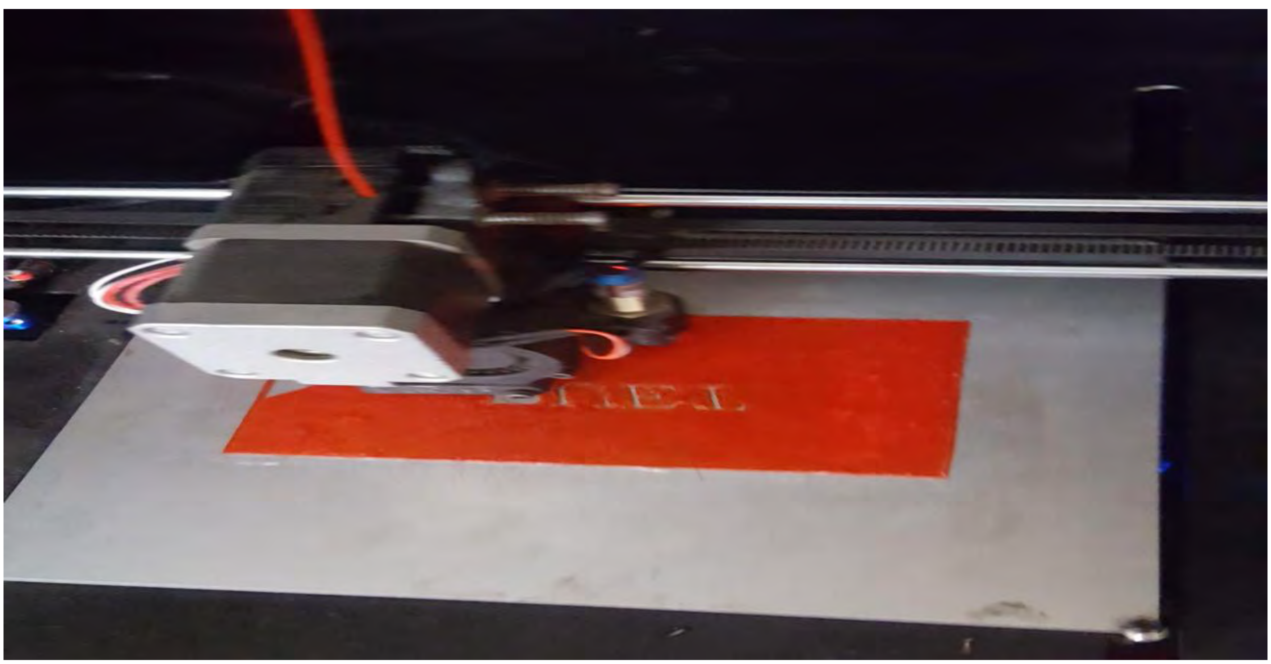

Figure 4.37: Lid Printing

Figure 4.38: Printed lid

4.17 Output of my product

After BOX and Lid print I got output which is showing by figure 4.39.

Figure 4.39: casing print using 3D printer

4.18 Performance and Cost Comparison of traditional and 3D printing technology

The Advantages of 3D Printing

Manufacturing Options: 3D printing provides a wide variety of manufactured products, including customizable products and even an individual’s personal designs.

Rapid Prototyping: Products can more quickly go from just a design to an actual prototype.

Manufacturing Speed: Just like the previous advantage, the manufacturing speed for a large number of final products is equally fast.

Reduced Costs: Even though the initial setup costs are higher, 3D printing has become cheaper than cheap labor in third world countries. Additionally, the costs of 3D printing are still decreasing, with the potential of 3D printers in homes in the near future. Furthermore, the costs of customized products are the same for mass production products.

Warehousing: With traditional manufacturing technologies, it is much faster and cheaper to manufacture additional products that you probably know that you will eventually need. However with 3D printing, only products that are sold need to be manufactured, thus warehousing of excess inventory is significantly less needed.

Chapter 5

Conclusion

5.1 Conclusion

Time to market (TTM) is very much critical for the success and profitability of any product especially for an electronic product since the world business market is very much competitive. This project is an initiative to have an exposure how an electronic product can be designed and developed using 3D printing technology. An Educational Kit (EduKit) for teaching and learning of microcontroller has been used as a case study. 3D printer and CNC machine facility of IICT, BUET have been used for the said development. A number of software such as Eagle for schmeatic and PCB design, Fusion 360 for CAD design for the casing and generation G-code have been used for the whole process. So a very excellent exposure has been achieve through this project. Moreover this project has offered an opportunity to work in hands on different kinds of machine. The setting of different tools and configuration has been done locally by trial and error for accurate and proper functioning of the machine. A very nice PCB has been fabricated using the CNC machine which once consumes a lot of hassles and time for making it from China. Then a very nice casing has been manufactured using the 3D printers which once were manufactured from plastic industry after waiting months after months. This hand on experience with software and machine can be utilized for commercial product development in future.

5.2 Suggestion for Future Work

3D printing technology is having tremendous opportunity for working in the international market. So some more complex product and casing can be developed using the CNC machine and 3D printers available in the lab of IICT, BUET which in turn will give huge hands on experience and confidence to work in the global market.

References

[1] https://searchcio.techtarget.com/definition/ICT-information-and-communications-technology-or-technologies

[2] Eric M., Rudy S. et al., “3D Printing for the Rapid Prototyping of Structural Electronic”, IEEE transaction of practical innovation, Vol 2, 2014.

[3] https://en.wikipedia.org/wiki/3D_printing;last access on 10 Nov, 2018

[4] https://www.marlinwire.com/blog/3d-printing-vs-traditional-manufacturing; last on 10 Nov, 2018

[5] Mohsen A., “The rise of 3-D printing: The advantages of additive manufacturing over traditional manufacturing”, Elesevier journal of Science and Technology , 2017

[6] Peng W.,Jun W., Xiangyu W., “ A critical review of the use of 3-D printing in the construction industry”, Elesevier journal of Science and Technology , 2016

[7] https://www.sculpteo.com/en/3d-printing/3d-printing-and-traditional-manufacturing-processes/; last access on 10 August, 2018