MINI CNC PLOTTER USING DVD WRITERS

A Mini Project Report

submitted in partial fulfilment of the requirement for the award of the degree

Bachelor of Engineering

In

Electronics and Communication Engineering

Submitted by

KOMMA SANDEEP REDDY	**1MJ19EC063**
LAKSHMAN REDDY M	**1MJ19EC064**
M SANTOSH	**1MJ19EC065**
MOHAMMED MAAZ	**1MJ19EC077**

Under the Guidance of

Dr. I. HAMEEM SHANAVAS

Professor, HOD of Electronics and Communication Engineering

MVJ College of Engineering, Bengaluru

(An Autonomous Institute)

Affiliated to VTU, Belagavi, Approved by AICTE, New Delhi,
Recognised by UGC with 12(f) & 12 (B), Accredited by NBA & NAAC

AUGUST 2022

MVJ COLLEGE OF ENGINEERING, BENGALURU-560067

(Autonomous Institution Affiliated to VTU, Belagavi)

DEPARTMENT OF ELECCTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

Certified that the mini project work titled ***'MINI CNC Plotter Using DVD Writers'*** is carried out by **KOMMA SANDEEP REDDY (1MJ19EC063), LAKSHMAN REDDY M (1MJ19EC064), M SANTOSH (1MJ19EC065),** and **MOHAMMED MAAZ (1MJ19EC077)** who are confide students of MVJ College of Engineering, Bengaluru, of **Bachelor of Engineering in Electronics and Communication Engineering** of the Visvesvaraya Technological University, Belagavi during the year 2021-2022. It is certified that all corrections/suggestions indicated for the Internal Assessment have been incorporated in the mini project report deposited in the departmental library. The mini project report has been approved as it satisfies the academic requirements in respect of mini project work prescribed by the institution for the said Degree.

Signature of Guide	Signature of Head of the Department	Signature of Principal
Dr. I. Hameem Shanavas Professor & HOD Department of ECE MVJ College of Engineering Bengaluru	**Dr. I. Hameem Shanavas** Professor & HOD Department of ECE MVJ College of Engineering Bengaluru	**Dr. P. Mahabaleshwarappa** Principal MVJ College of Engineering Bengaluru
_____	_____	_____

External Viva

Name of Examiners	Signature with Date
1	
2	

MVJ COLLEGE OF ENGINEERING, BENGALURU-560067

(Autonomous Institution Affiliated to VTU, Belagavi)

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

DECLARATION

We**, KOMMA SANDEEP REDDY (1MJ19EC063), LAKSHMAN REDDY M (1MJ19EC064), M SANTOSH (1MJ19EC065),** and **MOHAMMED MAAZ (1MJ19EC077)** students of Sixth semester B.E., Department of Electronics and Communication Engineering, MVJ College of Engineering, Bengaluru, hereby declare that the mini project titled ***'MINI CNC Plotter Using DVD Writers'*** has been carried out by us and submitted in partial fulfilment for the award of Degree of **Bachelor of Engineering** in **Electronics and Communication Engineering** during the year 2021-2022.

Further we declare that the content of the dissertation has not been submitted previously by anybody for the award of any Degree or Diploma to any other University.

We also declare that any Intellectual Property Rights generated out of this project carried out at MVJCE will be the property of MVJ College of Engineering, Bengaluru and we will be one of the authors of the same.

Place: Bengaluru

Date:

Name **Signature**

1. **KOMMA SANDEEP REDDY** (1MJ19EC063)
2. **LAKSHMAN REDDY M** (1MJ19EC064)
3. **M SANTOSH** (1MJ19EC065)
4. **MOHAMMED MAAZ** (1MJ19EC077)

ACKNOWLEDGEMENT

The satisfaction and euphoria that accomplishes the successful completion of any task would be incomplete without the mention of the people who make it possible.

I am thankful to **The Management** of MVJ College of Engineering, Bengaluru, for their continuous support and encouragement for carrying out the mini project work.

I thank **Dr. P. Mahabaleshwarappa**, Principal, MVJCE, Bengaluru for the encouragement and valuable suggestions.

I like to express my gratitude to **Dr. M. Brindha**, Vice principal, MVJCE, Bengaluru, for constant encouragement throughout the course.

I would like to express my sincere gratitude to **Dr. M. A. Lourdu Antony Raj**, Registrar & Controller of Examination, MVJCE, Bengaluru, for persistent guidance.

I thank **Dr. I Hameem Shanavas**, Professor and HOD, Department of Electronics and Communication Engineering, MVJCE, Bengaluru, for being a constant support and providing all the facilities that was needed in the mini project work.

I avail this opportunity to express profound sense of gratitude and thank to my guide. I would like to thank **Dr. I Hameem Shanavas**, Professor and HOD, Department of Electronics and Communication Engineering, MVJCE, Bengaluru, for his wholehearted support, suggestions and invaluable advice throughout our mini project work and also for the help in the preparation of this report.

I also express our gratitude to our panel members **Dr. Utsab Banerjee,** Assistant Professor and **Prof Sayantam Sarkar** , Assistant Professor, Department of Electronics and Communication Engineering, MVJCE, Bengaluru, for their valuable comments and suggestions.

I am in debt to the support of all the teaching and non-teaching members of Department of ECE, MVJCE, for their kind help and co-operation, throughout the mini project.

M SANTOSH

ABSTRACT

A Computer Numerical Control (CNC) plotter machine is a computerized numerical control machine which can be used to draw anything or design any mechanical parts according to the design program. The utilization of CNC machine is increased rapidly due to the growth of technology in industries. The fabrication of a low-cost CNC plotter becomes a persistent need.

Today the Growth of Technology and utilization of CNC machine are Rapid increased. The idea Behind Our Project is to Design a low-cost MINI CNC plotter machine with using Arduino, CNC shield and DVD Writers, it is capable to design machine mechanical parts and 2d design. This is fabrication of low-cost CNC Machine and decreased cost and complexity. This Paper is helping to design and fabrication of mini–CNC Plotter Machine. In this machine only G codes are used to command or instructions. G codes are language, by using this person Told computer control machine tool.

In this paper, a low cost, small size, and accurate mini-CNC plotter is designed using simple and low-cost components: a microcontroller (Arduino), stepper and servo motors and their control software. Software has been used to produce a G code for the operation of the system; G code is an effective language in which people tell the machine tools ‘How to make something’. G code allows the machine to sketch the plots by converting the instructions of that plot into a readable format by the motor driver telling these motors where to move & how fast to move.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Computer Numerical Control (or CNC) is an advanced form of automatic machine that used widely to control the motion of these machine tools. Numerical control machine was first invented around in 19th century to minimize the load of the work. Its advantage ensures higher efficiency, higher flexibility, and low production cost, a little working time, and a little loss in production. It mainly follows three steps that are receiving data, interpreting them and react accordingly. To direct the machine function, a special codes and form sequential commands (instructions) that are used to operate the machine automatically and to produce a specific part with specific dimension. These instructions (program) are then converted into an electrical signal and act as input to the motors which run the machine and do the basic movements. A machine control unit (or MCU) decides the tool depth of draw, drawing speed etc. Motion of tool is based on Right hand coordinate system.

Low-cost Mini CNC plotter machine is described as it is based on Arduino controller and CNC shield. CNC is computer numerical control machine. G codes are preparatory Function. G codes are pre-defining Function Associated with the movement on machine axes. In CNC Plotter Machine only G codes are used. G codes are giving the Direction to move the pen in X, Y, Z directions. Pen can be changed by tools of drilling, laser cutting tool, milling it can be worked, if it is made in large size. The aim of over is to make a mini-CNC plotter machine which is capable to draw difficult design in paper or surface of metal, to cut it with a great accuracy. We have used 3 stepper motors with lead screw in Cartesian coordinate X, Y, Z directions. Stepper motor convert digital pulse into lead screw rotations. Stepper drivers are used to give command to the system. The main aim is to fabricate a Low-Cost MINI CNC plotter Machine to draw an object with using G codes.

Cost of the project and increase Reliability and Flexibility. In we have replace pen with mechanical tools drilling, grinding, machining etc. This will be used for soft material cutting or machining, laser cutting machine tool is also worked on this setup.

The use of technology in education has become indispensable. However the cost associated with the advanced technologies is very high. Computers, softer and the interface which is available between the hardware and software has taken education a step ahead of the old days were visualization, verification was so very difficult. Low-cost robots serve a lot of purpose in education. Plotters are generally use to make 2D plots which is digitally controlled. This 2D plots CNC machine can be replaced by higher specific laser sources which can be used for cutting of different materials of different strength in 3D plots. The 2D plotter is designed to recording and plotting two dimensional data on a rectangular coordinate system

We have reduced the cost, in the setup of mini CNC plotter machine.Mini CNC plotter machine is described as it is based on Arduino controller and CNC shield. CNC is computer numerical control machine. G codes are preparatory Function. G codes are pre-defining Function Associated with the movement on machine axes. In CNC Plotter Machine only G codes are used. G codes are giving the Direction to move the pen in X, Y, Z directions. Pen can be changed by tools of drilling, laser cutting tool, milling it can be worked, if it is made in large size. The aim of over is to make a mini CNC plotter machine which is capable to draw difficult design in paper or surface of metal, To cut it with a great accuracy. We have used 3 stepper motors with lead screw in Cartesian coordinate X, Y, Z directions. Stepper motor is convert digital pulse into lead screw rotations. Stepper drivers are used to give command to the system. The main aim is to fabricate a MINI CNC plotter Machine to draw an object with using G codes.

CHAPTER 2

LITRETURE SURVEY

Various authors have studied the development of such machines. 'Fabrication of Low Cost 3-Axis CNC Plotter Machine.

1. Venkata Krishna Pabolu et al. Nov 2010: "Design & Implementation of a three-Dimensional CNC Machine". It increases the demand for flexibility and cutting with respect to edge quality. It maintains the accuracy and reliability for complex shapes. In this system they used visual C# as a language on .NET platform. In this there are three main kinds of computerized numerical controllers: 1.Multiprocessor with ASIC, 2. PC front end, 3. Motion control card with PC. The design of this system is user-friendly one which give accurate results and also flexible to users. RTOS is very costlier and not user friendly and with such system it is not possible to implement on any general PC, where user must purchase the operating system.
2. Sundar Pandian 2014 : "develop low cost 3 axis CNC machine". It is low cost, and it is used currently in the laboratory. Stepper motors with drivers, Arduino open source, and microcontroller and open-source motor control software. Author used ready to assemble kit from Zen Tool works, USA. Kit provided stepper motor, lead screw, guide rod, anti-backlash falans and spring. He made the Body with high density PVC. The machine has fix gantry and mobile bed so there is restriction in working area. The model provides more scope for handson learning by the students and therefore better learning outcomes. It is developed for only educational purpose.
3. Kajal J. Madekar, Kranti R. Nanaware, Pooja R. Phadtare, Vikas S. Mane Feb 2016 "Automatic mini–CNC Machine for PCB drawing". To develop low-cost automatic mini CNC machine for PCB drawing. This system reduces the cost of machine and increases the flexibility. In this G code is interfaced with ATMEGA 328. CNC based controller by FTDI module which is used to convert the code in convenient controller the code i.e., serial to USB converter, x moves to left, Y moves to right and z moves to up and down. It gives better accuracy and reduces the workload. G code mark easy to find the information of

locations of all stepper motor moving. In the GRBL support 3 axis of motion X, Y and Z but does not support rotation axes (X, Y).

CHAPTER 3

METHODOLOGY

We have supplied the current in Arduino with USB DATA cable to transfer Data from Computer to Arduino Board [1], Here we have used 3 Stepper Drivers to supply the G codes in Sequence to thestepper motors. Arduino will be mounted on CNC shield. CNC shield will be distributing the Current in the command of Arduino. CNC shield will be converting the command of G codes in digital pulse by Stepper motor. In X direction Stepper motor will be move left and Right, Y direction stepper motor will be move in front and back direction, Z direction Stepper motor will bemove in Up and down [2]. We have made much difficult design via using this machine. The accuracy of this machines result is very high. So, we have used in industry to reduce the cost of design printing and maintain accuracy level. Drafting and Scaling of CNC Plotter machine is very precious

3.1 Design of CNC Machine

There are 3 movements of using 3 CD ROMs. The horizontal movement(X) i.e., forward & backward movement is provided by the lower CD Rom. The 2nd CD Rom is mounted between the2 columns which provide side movements(Y) i.e., left- and right-hand side movements. The spindle which is mounted on the 3rd CD Rom provides vertical movement (Z) for feed of tool as shown in figure 3.1.

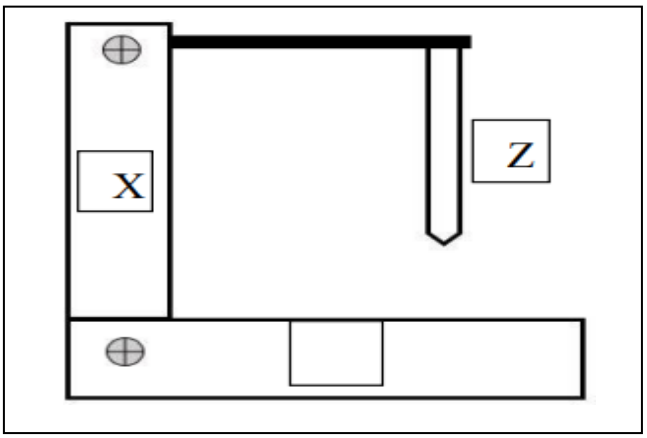

Figure 3.1 DESIGN OF CNC MACHINE

3.2 Problem Definition

The available Arduino controlled CNC machines are having only 2 axis movement. The structure is weak and can machine foam only

3.3 Working

We have supplied the current in Arduino with USB DATA cable to transfer Data from Computer to Arduino Board [1], Here we have used 3 Stepper Drivers to supply the G codes in Sequence to thestepper motors. Arduino will be mounted on CNC shield. CNC shield will be distributing the Current in the command of Arduino. CNC shield will be converting the command of G codes in digital pulse by Stepper motor. In X direction Stepper motor will be move left and Right, Y direction stepper motor will be move in front and back direction, Z direction Stepper motor will be move in Up and down [2]. We have made many difficult designs via using this machine. The accuracy of these machines results is very high. So, we have used in industry to reduce the cost of design printing and maintain accuracy level. Drafting and Scaling of CNC Plotter machine is very precious

3.4 Main Parts of CNC Plotter

Mini CNC Plotter Machine is worked on input as a G code of Design and Converting it via use of Arduino, Stepper Drivers, CNC Shield, Stepper Motor in to a Rotation of Lead

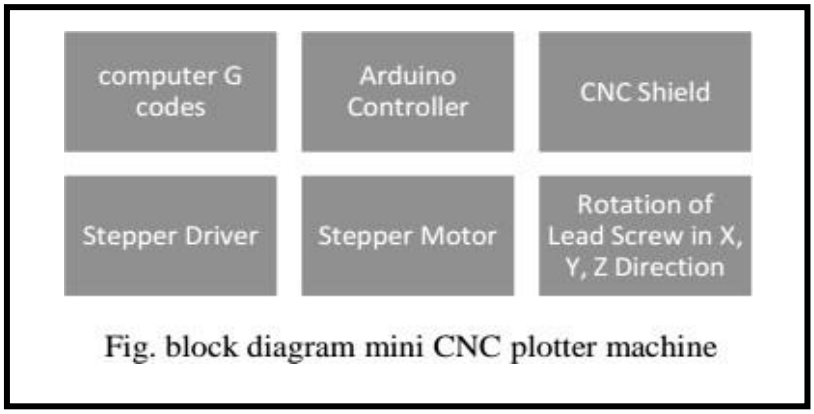

Figure 3.2 Main parts of CNC Plotter

screw. We have work on to maintain lowest cost of our project. We have designed a simple construction of our project. This is easier way to use stepper motor with lead screw, CNC shield, Stepper drivers, Arduino Board, etc. The Setup of machine is flexible that's why it will be easily transported and Maintenance time is short. The basic diagram of CNC Plotter machine is shown in figure 3.2.

3.5 Block Diagram of Process

In this idea of project, Arduino microcontroller platform with ATMEGA 328 core is used. It can be easily interfaced with PC using FTDI module whereas also with the easy drivers and stepper motors to. The basic block diagram is as shown in figure 3.3 The explanation is given as follows

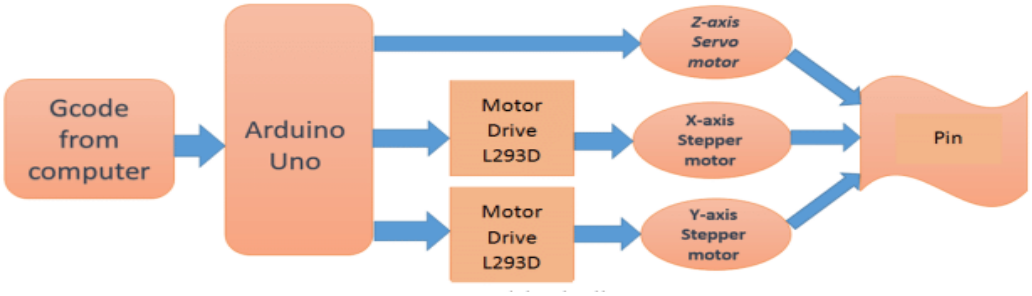

Figure 3.3 Block Diagram

CHAPTER 4

HARDWARE DESCRIPTION

4.1 Introduction about Arduino Uno

Arduino will be defined as; it is received the command or data from the computer and with the help of USB cable as shown in figure 4.1. It is mounted on CNC shield, it will be transfer data from Arduino to CNC shield with using stepper driver. Arduino UNO is a microcontroller board, it contains everything needed to support the microcontroller, simply connect it to a computer with a USB cable and a power source. It controls the position of steppermotor with help of a program [2]. It is open-source platform based on easy-to-use hardware and software. T have digital and analog input/output pins which can interface into various expansion board and other circuits and microcontroller with complementary components that helps in programming and incorporation into other circuits [3]. Current supplied 5 volts with USB cable.

Figure 4.1 Arduino UNO

4.2 Introduction about A4988 Stepper Motor Driver

The A4988 is a complete micro stepping motor driver with built-in translator for easy operation. It is designed to operate bipolar stepper motors in full-, half-, quarter-, eighth-, and sixteenth-step modes, with an output drive capacity of up to 35 V and ±2 A as shown in figure 4.2. The A4988 includes a fixed off-time current regulator which has the ability to operate in slow or mixed decay modes.

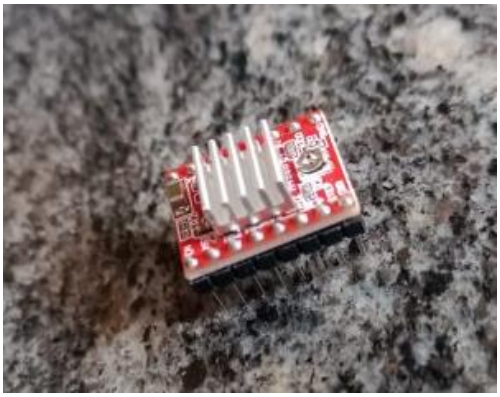

Figure 4.2 A4988 Stepper Motor driver

4.3 Introduction about Mini Servo Motor

A servo motor is an entirely different story the function of the servo is to receive a control signal that represents a desired output position of the servo shift and apply power to its Dc motor until its shaft turns to that position as shown in figure 4.3.

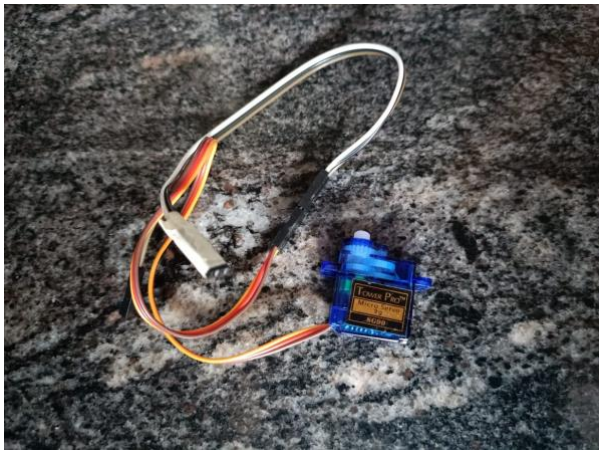

Figure 4.3 Servo Motor

4.4 Disassembly DVD/CD Drives

First step to start building this CNC machine is to disassemble two DVD/CD drives and take off the stepper motors as shown in figure 4.4. Use the screwdriver to open them and take off them the rails. Next step is to choose our base for this CNC machine. I used one surface from remaining DVD garbage' stuff. Finally, we will need to find something toattach the one of the stepper-rails vertically to our construction. (You will understand what I mean in our next step) Watch the above image.

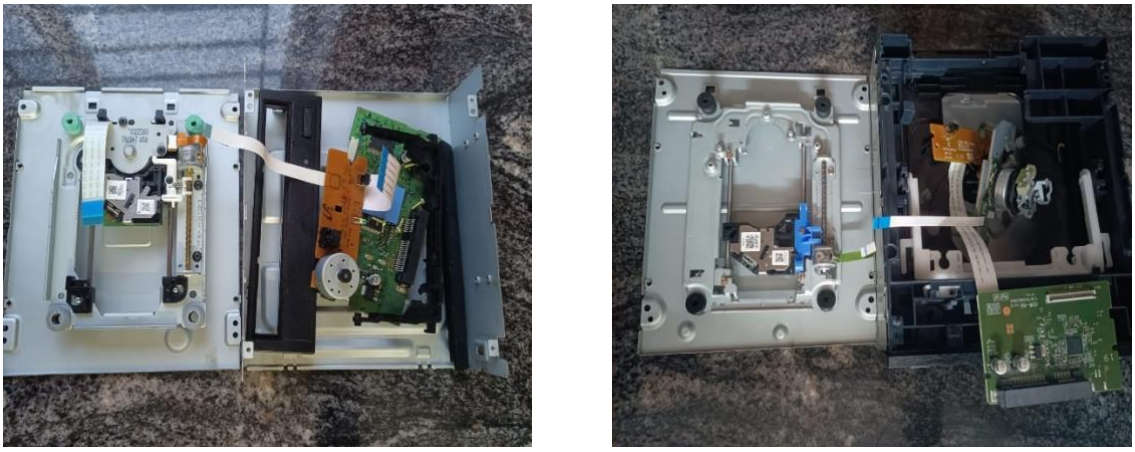

Figure 4.4 Disassembly

1. 1st Stepper motor with rails.
2. 2nd Stepper motor with rails.
3. This metal will be our CNC base.
4. We will cut this plastic to attach on it later one of the stepper-rails.

4.5 Introduction about Stepper Motors

Stepper can be converted digital pulse in to a movement of pen with respect to axis X, Y, Z direction. A stepper motor is a brushless motor that divides a full rotation into a number of equal steps, the stepper motor is known by its property to convert a number of impulses into a defined increment in the shaft position. Each pulses move the shaft through a fixed angle. We have used 3 stepper motors with lead screw. Motor output will be in the form of rotation of lead screw.

4.6 X and Y axis

In first image above you will see the Y axis of our CNC machine. Attach it on your surface, in this part you will need some screws and nuts in second image you will see the X and Y axis. The X axis is attached to two plastic parts that I took from remaining 'garbage' stuff as shown in figure 4.5. I cut it to fit the construction. This is an easy procedure. Justmake sure to put the Y axis straight to CNC base and the X axis vertically in this (90 degrees) as shown in figure 4.6.

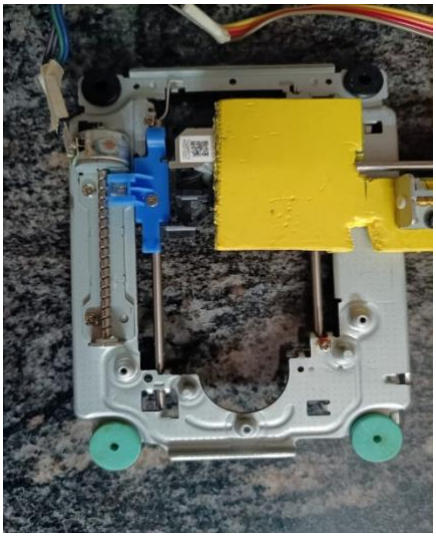

Figure 4.5 X-axis

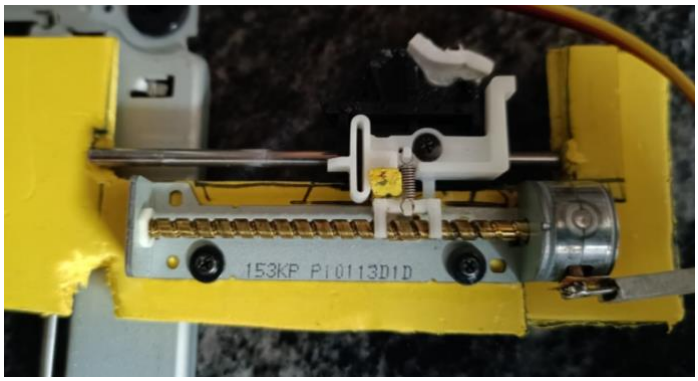

Figure 4.6 Y-axis

4.7 Z-axis

That's the most difficult part of our construction. You will need something to attach it on X axis, a flat surface. On that surface you will attach the servo motor (Z axis) and the pen base. Pen (or pencil) must be able to move up and down with the help of servo motor. Watch the above image to understand what you need to do to build Z axis as shown in figure 4.7. Servo motor must be able to move up and down the pen.

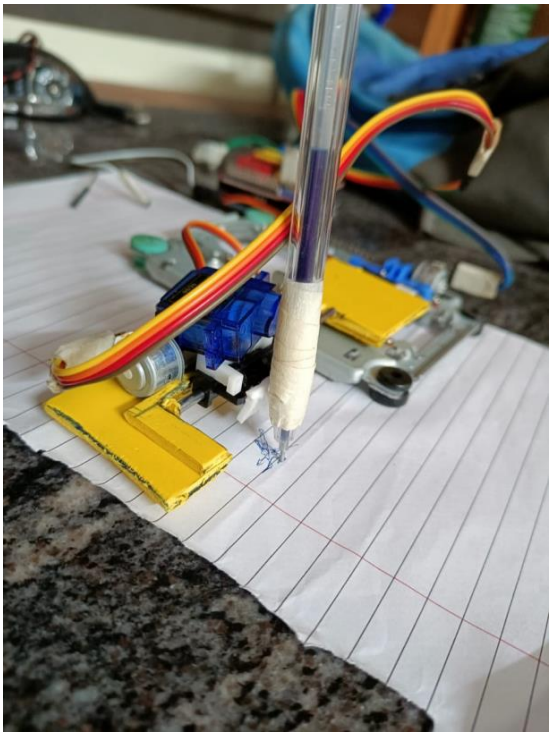

Figure 4.7 Z-axis

4.8 Paper Base

Now you will have to attach a wood (or plastic) surface on Y axis (5x5cm will be fine) as shown in figure 4.8. On thisyou will put the paper piece to print your texts or images Remember, printing area is 10cmx10cm.

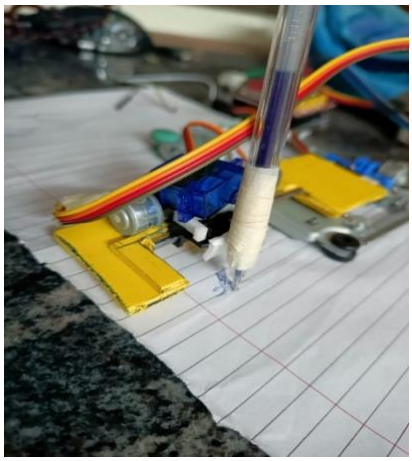

Figure 4.8 Paper Base

4.9 The Circuit

Circuit and Wiring

The wiring of the various components of electronics system is represented in the figure 4.9. The microcontroller of Arduino board is connected to the computer system through the USB serial port. The Stepper Motors of three axes (X, Y and Z) are connected with CNC shield driver board as shown in figure 4.9. D.C. Power supply is provided for all the components of electronics system.

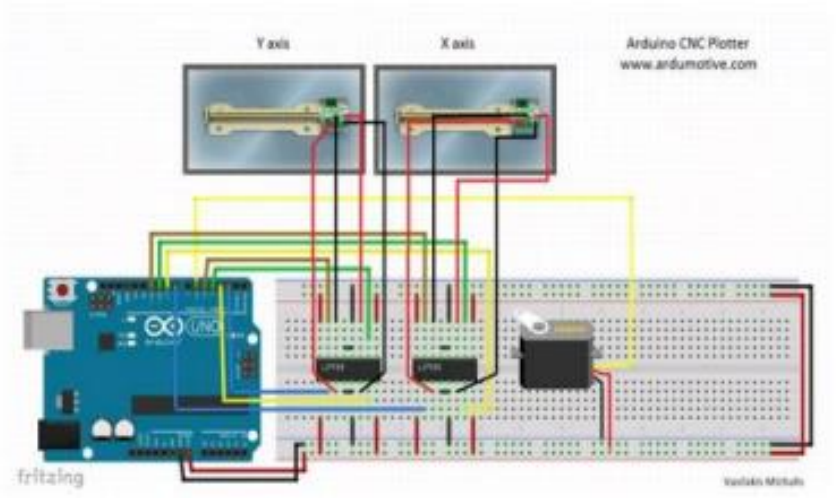

Figure 4.9 Circuit Diagram

CHAPTER 5

SOFTWARE DESCRIPTION

5.1 Arduino IDE

The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board"(https://www.arduino.cc). It is simplified C/C++ functions language based programming can be download functionality with a rich set of library functions. After download and install on pc can be write the program by C language and from tools and port must be choose the port connection between computer and Arduino through USB. After this step can be verify the program by error checking and the message is done compiling when it finished and no error. After this step can be upload the program on the Arduino as shown in figure 5.1.

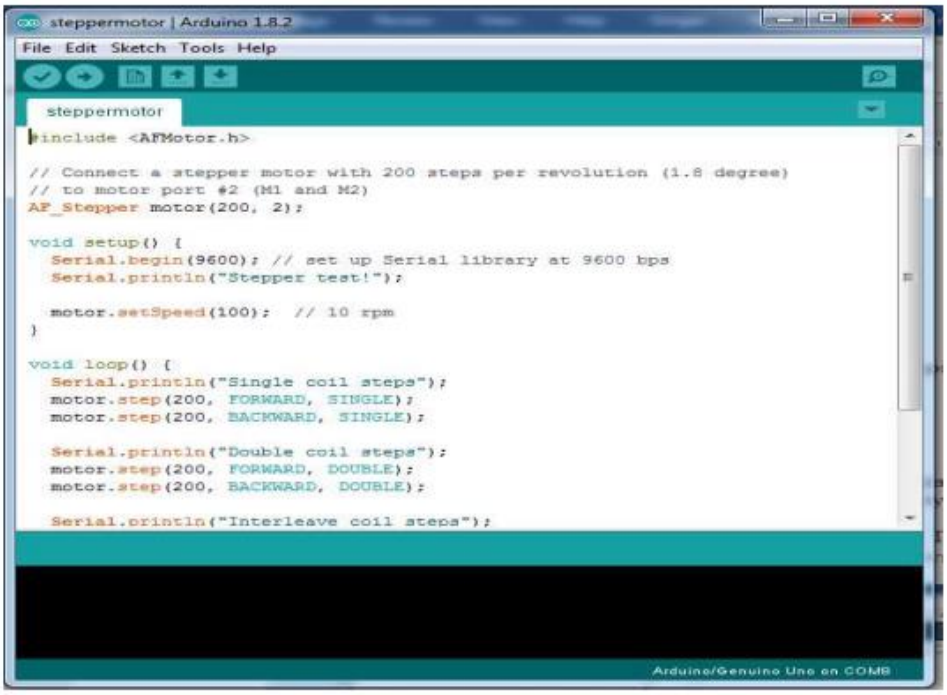

Figure 5.1 Arduino IDE

5.2 BENBOX

It is an open-source software used for mini-CNC plotter and laser engraver machine. This software converts an 2D image into G Code. Using this software we can control the speed, accuracy, width and length of the print. We can also use the pause and resume feature.Using this software, we can create our own 2D objects like Text, Drawings, Photos,etc. as shown in figure 5.2.

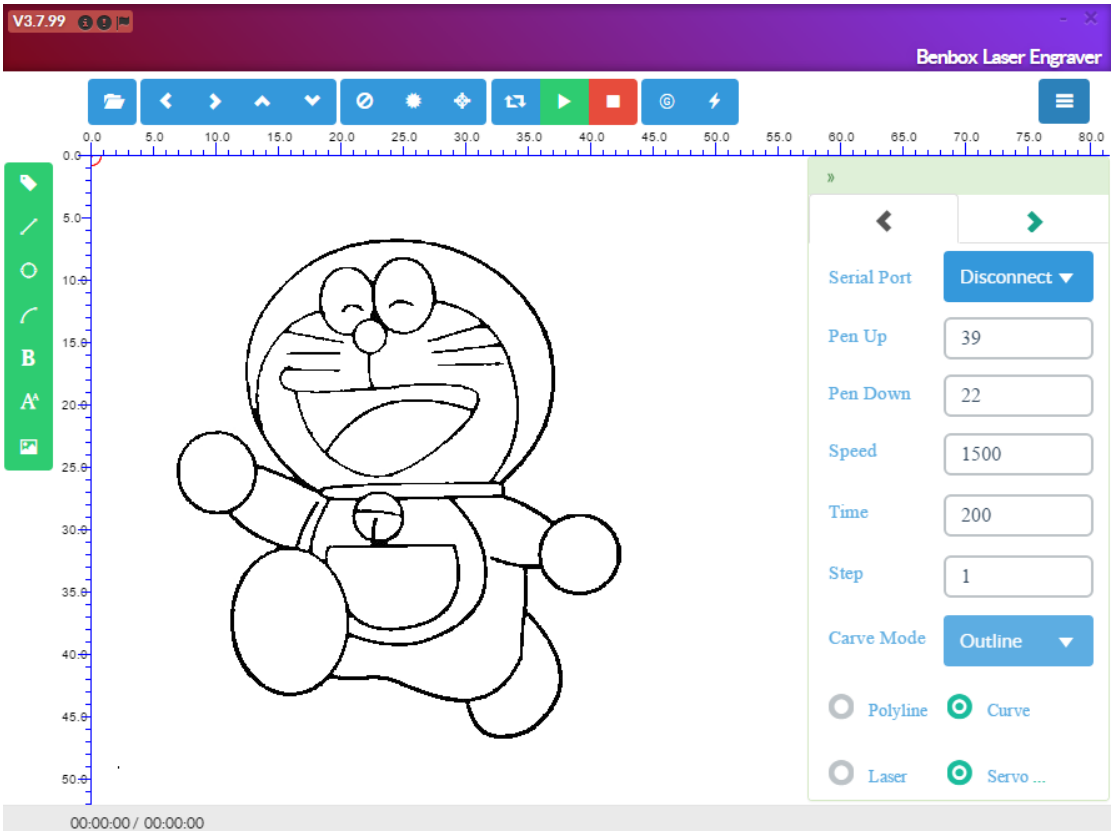

Figure 5.2 BENBOX

CHAPTER 6

RESULT AND ANALYASIS

We have supplied the current in Arduino with USB DATA cable to transfer Data from Computer to Arduino Board [1], Here we have used 3 Stepper Drivers to supply the G codes in Sequence to thestepper motors. Arduino will be mounted on CNC shield. CNC shield will be distributing the Current in the command of Arduino. CNC shield will be converting the command of G codes in digital pulse by Stepper motor. In X direction Stepper motor will be move left and Right, Y direction stepper motor will be move in front and back direction, Z direction Stepper motor will be move in Up and down [2]. We have made many difficult designs via using this machine. The accuracy of these machines results is very high. So, we have used in industry to reduce the cost of design printing and maintain accuracy level. Drafting and Scaling of CNC Plotter machine is very precious

6.1 Testing X and Y axis Movement

Here is the X and Y axis testing code embedded using code bender For X axis: For Y axis: If you see any movement here that means that the stepper motors wiring is correct! as shown in the figure 6.1. if you don't, try to change the cables.

6.2 Uploading the CNC Code

Here is the main CNC code embedded using code bender in this part you will see your pen goes up. If don't, change pen Up and pen Down variables that controlling the servo motor. Press the "Run on Arduino" button and program your board from your browser

6.3 The OUTPUT

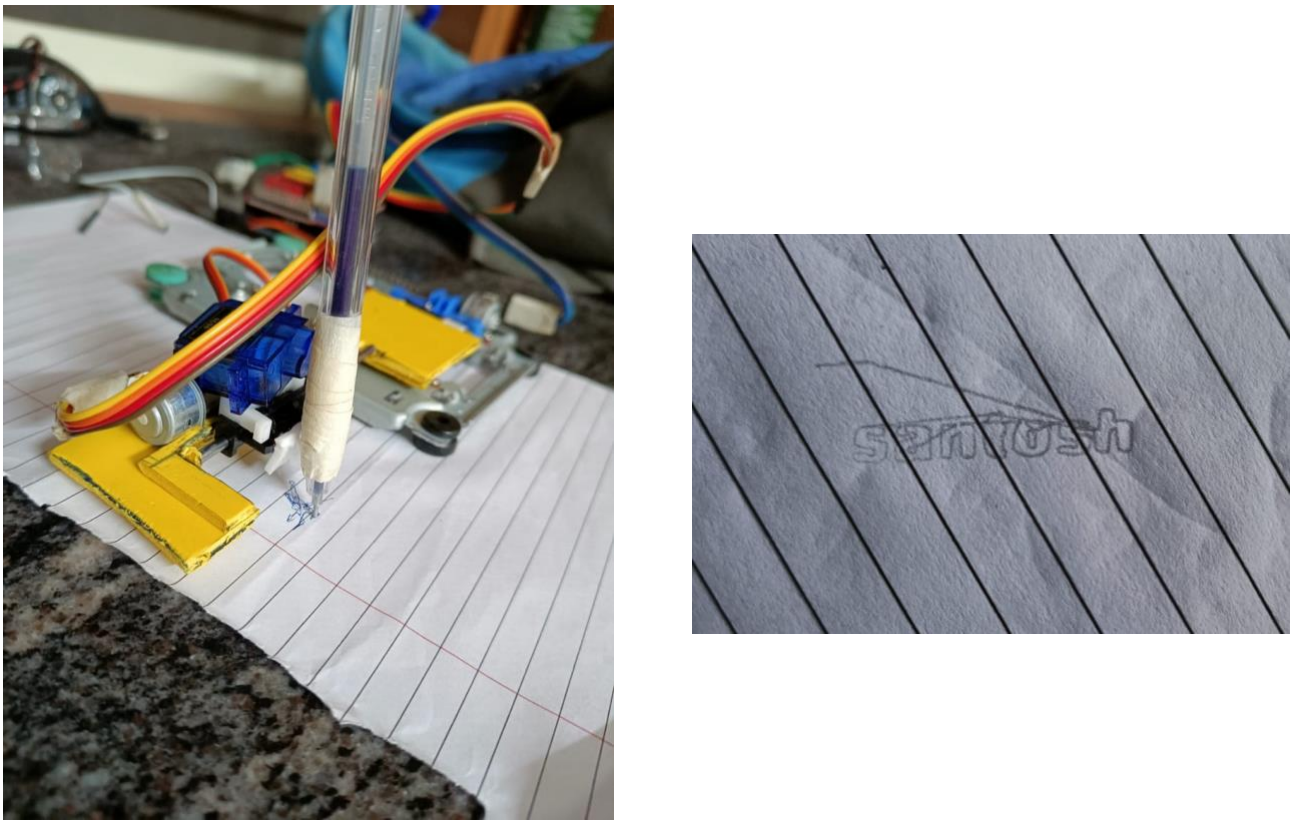

Figure 6.1 THE OUTPUT

6.4 CNC Machine Advantages

1. CNC machines can be used continuously 24×7 throughout the year and only need to be switched off for occasional maintenance.

2. CNC machines are programmed with a design which can then be manufactured hundreds or even thousands of times. Each manufactured product will be exactly the same.

3. Less skilled/trained people can operate CNC machines unlike manual lathes / milling machines etc. which need skilled engineers.

4. CNC machines can be updated by improving the software used to drive the machines.

5. Training for correct use of CNC machines is available through the use of 'virtual software'. This software is like a computer game that allows the operator to practice using the CNC machine on the screen of a computer.

6. Modern design software allows the designer to simulate the manufacture of his/her idea. There is no need to make a prototype or a model. This saves time and money.

7. One person can supervise many CNC machines as once they are programmed; they can usually be left to work by themselves. Only the cutting tools need replacement occasionally.

6.5 CNC Machine Disadvantages

The machine runs in a slow pace and generates excess heat which causes the heat sinkto be heated quickly. A slight error may remain on the image file after it has been plotted due to one side of the Y-axis fixed to the moving mechanism and the other endis free to move. The Z-axis is not very rigid so it causes slight vibration.

6.6 Applications

- Compact CNC/3D Printery Brijesh Sondarva
- Mini CNC Foam Cutter by Jonahmarrs
- Mini Arduino CNC by me_ zain
- CD/DVD Bipolar Motor Driver W/o Microcontroller by Samiran
- CNC Stomp Pad Project | Pad Project |G-Code Programming CNCPlasma Cutting byivanirons
- L293D driver board for CNC by Brijesh Sondarva

CHAPTER 7

CONCLUSION

In this paper we have presented the concept of a low cost three-axis mini CNC plotter. The existing CNC machines are of high cost, difficult to maintain and requires highly skilled operators. Our CNC plotter overcomes these problems. It is of low cost and easy to control and there is no need of highly skilled operators.It can be used for long hours at a stretch which is not possible in existing ones. It is hoped to extend this work for future development.

It is a low-cost mini-CNC plotter machine, which can be easily controlled with computer and can be suddenly stopped and paused by click action on computer.By using this we can make Difficult and Complex Design in paper.This is small machine which is easily Transportable and Assembled anywhere on Requirement of it.On the successful work of this machine, we can have some changes on it and make it commercial used and applying tools for cutting, grinding of soft material etc.

This setup of hardware with a combination of G-code gives better accuracy and reduces the work load. G code make easy to find the information of locations of all stepper motor moving, as the status of our moving motor are directly seen on computer hence we can start or stop the machine whenever we are needed. Making a small machine brings an flexibility to do work

FUTURE SCOPE:

The pen of the machine can be replaced by a laser to make it work like a laser engraving or cutting machine. Engraving machine can be used on wood. The pen can also be replaced with a powerful drill so that it can be used for both milling and drilling purposes. The servo can be replaced with a stepper motor and the pen with a 3-D pen to make it a 3-D printer which can print objects with dimensions. By extrapolation of the axes, the working area of the machine can be extended keeping the algorithm unaltered

References

[1] Kajal J. Madekar1, Kranti R. Nanaware2, Pooja R. Phadtare3, Vikash S. Mane4, ―Automatic mini-CNC machine for PCB drawing and drilling, 'International Research Journal of Engineering and Technology (IRJET), Volume: 03; Issue: 02; Page No. 1106-1110; 2016.

[2] N. Balasubramanyam and Prof. Smt. G. Prasanthi ―Design and Fabrication of an Automatic PC- Based Drilling Machine‖, HCTL Open International journal of Technology Innovation and Research, Volume: 07, 2014.

[3] Nae and T. Andrei, "Designing and building a CNC router using stepper motors", Serial Technical, vo. LXII, pp. 55-62, 2016.

[4] I. Pahole, L. Rataj, M. Ficko, S. Klancnik, S. Brezovnik, M. Brezocnik, and J. Balic, "Construction and evaluation of low-cost table CNC milling machine", Scientific Bulletin, Series C: Mechanics, Tribology, Machine Manufacturing Technology, vol. XXIII, pp. 1-7, 2012.

[5] Wikipedia - https://en.wikipedia.org/wiki/Numerical_control

[6] YOUTUBE Channel – Concerning Reality - https://youtu.be/FNYEXjRmDtI

APPENDIX

```
#include <Servo.h>
#include <AFMotor.h>
#define LINE_BUFFER_LENGTH 512
char STEP = MICROSTEP ;
const int penZUp = 115;
const int penZDown = 83;
const int penServoPin =10 ;
const int stepsPerRevolution = 48;
Servo penServo;
AF_Stepper myStepperY(stepsPerRevolution,1);
AF_Stepper myStepperX(stepsPerRevolution,2);
struct point {
  float x;
  float y;
  float z;
};
struct point actuatorPos;
float StepInc = 1;
int StepDelay = 0;
int LineDelay =0;
int penDelay = 50;
float StepsPerMillimeterX = 100.0;
float StepsPerMillimeterY = 100.0;
float Xmin = 0;
float Xmax = 40;
float Ymin = 0;
float Ymax = 40;
float Zmin = 0;
```

```
float Zmax = 1;
float Xpos = Xmin;
float Ypos = Ymin;
float Zpos = Zmax;
boolean verbose = false;

void setup() {
  Serial.begin( 9600 );
  penServo.attach(penServoPin);
  penServo.write(penZUp);
  delay(100);
  myStepperX.setSpeed(600);
  myStepperY.setSpeed(600);
  Serial.println("Mini CNC Plotter alive and kicking!");
  Serial.print("X range is from ");
  Serial.print(Xmin);
  Serial.print(" to ");
  Serial.print(Xmax);
  Serial.println(" mm.");
  Serial.print("Y range is from ");
  Serial.print(Ymin);
  Serial.print(" to ");
  Serial.print(Ymax);
  Serial.println(" mm.");
}
void loop()
{
  delay(100);
  char line[ LINE_BUFFER_LENGTH ];
  char c;
```

```
int lineIndex;
bool lineIsComment, lineSemiColon;
lineIndex = 0;
lineSemiColon = false;
lineIsComment = false;

while (1) {
  while ( Serial.available()>0 ) {
    c = Serial.read();
    if (( c == '\n') || (c == '\r') ) {
      if ( lineIndex > 0 ) {
        line[ lineIndex ] = '\0';
        if (verbose) {
          Serial.print( "Received : ");
          Serial.println( line );
        }
        processIncomingLine( line, lineIndex );
        lineIndex = 0;
      }
      lineIsComment = false;
      lineSemiColon = false;
      Serial.println("ok");
    }
    else {
      if ( (lineIsComment) || (lineSemiColon) ) {
        if ( c == ')' )  lineIsComment = false;
      }
      else {
        if ( c <= ' ' ) {
        }
        else if ( c == '/' ) {
```

```
        }
        else if ( c == '(' ) {
          lineIsComment = true;
        }
        else if ( c == ';' ) {
          lineSemiColon = true;
        }
        else if ( lineIndex >= LINE_BUFFER_LENGTH-1 ) {
          Serial.println( "ERROR - lineBuffer overflow" );
          lineIsComment = false;
          lineSemiColon = false;
        }
        else if ( c >= 'a' && c <= 'z' ) {        // Upcase lowercase
          line[ lineIndex++ ] = c-'a'+'A';
        }
        else {
          line[ lineIndex++ ] = c;
        }
      }
    }
  }
}
void processIncomingLine( char* line, int charNB ) {

 int currentIndex = 0;
  char buffer[ 64 ];
  struct point newPos;
  newPos.x = 0.0;
  newPos.y = 0.0;
```

```
  while( currentIndex < charNB ) {
    switch ( line[ currentIndex++ ] ) {

case 'U':
      penUp();
      break;

case 'D':
      penDown();
      break;

case 'G':
      buffer[0] = line[ currentIndex++ ];
      buffer[1] = line[ currentIndex++ ];
      buffer[2] = '\0';
      buffer[1] = '\0';
      switch ( atoi( buffer ) ){                // Select G command
      case 0:                                   // G00 & G01 - Movement or fast movement. Same here
      case 1:
        char* indexX = strchr( line+currentIndex, 'X' );
        char* indexY = strchr( line+currentIndex, 'Y' );
        if ( indexY <= 0 ) {
          newPos.x = atof( indexX + 1);
          newPos.y = actuatorPos.y;
        }
        else if ( indexX <= 0 ) {
          newPos.y = atof( indexY + 1);
          newPos.x = actuatorPos.x;
        }

else {
```

```
        newPos.y = atof( indexY + 1);
        indexY = '\0';
        newPos.x = atof( indexX + 1);
      }
      drawLine(newPos.x, newPos.y );
      //       Serial.println("ok");
      actuatorPos.x = newPos.x;
      actuatorPos.y = newPos.y;
      break;
    }
    break;

case 'M':
    buffer[0] = line[ currentIndex++ ];
    buffer[1] = line[ currentIndex++ ];
    buffer[2] = line[ currentIndex++ ];
    buffer[3] = '\0';
    switch ( atoi( buffer ) ){
    case 300:
      {
        char* indexS = strchr( line+currentIndex, 'S' );
        float Spos = atof( indexS + 1);
        //       Serial.println("ok");
        if (Spos == 30) {
          penDown();
        }
        if (Spos == 50) {
          penUp();
        }
        break;
```

```
        }

case 114:
        Serial.print( "Absolute position : X = " );
        Serial.print( actuatorPos.x );
        Serial.print( "  -  Y = " );
        Serial.println( actuatorPos.y );
        break;
      default:
        Serial.print( "Command not recognized : M");
        Serial.println( buffer );

 }
    }
  }
}
void drawLine(float x1, float y1) {
 if (verbose)
  {

  Serial.print("fx1, fy1: ");
    Serial.print(x1);
    Serial.print(",");
    Serial.print(y1);
    Serial.println("");

  }

  if (x1 >= Xmax) {
    x1 = Xmax;
  }
```

```
 if (x1 <= Xmin) {
    x1 = Xmin;
  }

if (y1 >= Ymax) {
    y1 = Ymax;
  }
  if (y1 <= Ymin) {
    y1 = Ymin;
  }

if (verbose)
  {
    Serial.print("Xpos, Ypos: ");
    Serial.print(Xpos);
    Serial.print(",");
    Serial.print(Ypos);
    Serial.println("");
  }

if (verbose)
  {
    Serial.print("x1, y1: ");
    Serial.print(x1);
    Serial.print(",");
    Serial.print(y1);
    Serial.println("");
  }
```

```
 x1 = (int)(x1*StepsPerMillimeterX);
  y1 = (int)(y1*StepsPerMillimeterY);
  float x0 = Xpos;
  float y0 = Ypos;
  long dx = abs(x1-x0);
  long dy = abs(y1-y0);
  int sx = x0<x1 ? StepInc : -StepInc;
  int sy = y0<y1 ? StepInc : -StepInc;
  long i;
  long over = 0;

if (dx > dy) {


for (i=0; i<dx; ++i) {
      myStepperX.onestep(sx,STEP);
      over+=dy;
      if (over>=dx) {
        over-=dx;
        myStepperY.onestep(sy,STEP);
      }
    delay(StepDelay);
    }
  }
  else {
    for (i=0; i<dy; ++i) {
      myStepperY.onestep(sy,STEP);
      over+=dx;
      if (over>=dy) {
        over-=dy;
        myStepperX.onestep(sx,STEP);
```

```
    }
    delay(StepDelay);
   }
  }

  if (verbose)
  {

   Serial.print("dx, dy:");
   Serial.print(dx);
   Serial.print(",");
   Serial.print(dy);
   Serial.println("");

  }

  if (verbose)
  {

   Serial.print("Going to (");
   Serial.print(x0);
   Serial.print(",");
   Serial.print(y0);
   Serial.println(")");

  }
  delay(LineDelay);
  Xpos = x1;
  Ypos = y1;
}
```

```
void penUp() {


  penServo.write(penZUp);
  delay(penDelay);
  Zpos=Zmax;
  digitalWrite(15, LOW);
    digitalWrite(16, HIGH);
  if (verbose) {
    Serial.println("Pen up!");

  }
}
void penDown() {

  penServo.write(penZDown);
  delay(penDelay);
  Zpos=Zmin;
  digitalWrite(15, HIGH);
    digitalWrite(16, LOW);
  if (verbose) {
    Serial.println("Pen down.");

  }
}
```