

## CNC PLOTTER MACHINE

Syed Fazle Hyder<sup>1</sup>, Mohammed Ibrahim<sup>2</sup>, Mohd Zeeshan Adan<sup>3</sup>, Fazal Mohammed<sup>4</sup>

<sup>1,2,3</sup>Students of Mechanical Engineering Department, Nawab Shah Alam Khan College of Engineering and Technology, Hyderabad, Telangana, India.

<sup>4</sup>Assistant professor of Mechanical Engineering Department, Nawab Shah Alam Khan College of Engineering and Technology, Hyderabad, Telangana, India

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**Abstract:** In this project we are designing a low cost three axis CNC Plotter machine using stepper motor, Arduino Uno R3, micro controller software. The Software has been used to produce a G code for the operation of the system. The Arduino plotter machine has been dependent on the principle of Computer Numerical Control with limited area depends on the motion X, Y and Z axes. Basically, the system of this plotter machine is modeling by solid work software to work with three axes stepper motors (as X, Y and Z axes), these three stepper motors are controlled by shield for movement (X, Y and Z axes). This machine's movement on the X axis is 215 mm and Y axis is 235 mm. Length of travel means the linear movement of stepper motors that control for X, Y and Z axes from point to another point. The left and right movement controlled by X axis stepper motor, front-back movement controlled by Y axis stepper motor and the pen is up-down that is controlled by Z axis stepper motor

**Key Words:** CNC, Arduino, G code, Micro controller unit.

### 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 numbers 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 in to 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. Three axis of rotation (x, y & z) for three dimensional motion of tool and for specific role plus an axis of rotation. The x-axis serves as height stands and uses two pieces one for front and one for back. The y-axis acts as motor mount to move z-axis in

addition with slide mechanism whereas the z-axis controls the depth by allowing the movement of router in up and down direction so it is very important axis.

### 2. LITERATURE REVIEW:

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

**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 also with such system it is not possible to implement on any general PC, where user has to purchase the operating system.

**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 hands-on learning by the students and therefore better learning outcomes. It is developed for only educational purpose.

**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 work load. G code mark easy to find the

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

### 3. TECHNICAL SPECIFICATIONS:

#### 3.1 Stepper Motor:

A stepper motor is a brushless DC electric motor that divides a full rotation into a number of equal steps. Stepper Motors represent the heart of CNC plotter. Two stepper motors are used for x and y axis for precise control over drawing pen (sketching unit) for object sketching. They have important role such that they control the size and type of speed, accuracy, CNC router precision etc. . . .



Fig 1: Stepper motor

The axis of CNC machine (x, y & z) is based on the right hand coordinate system.

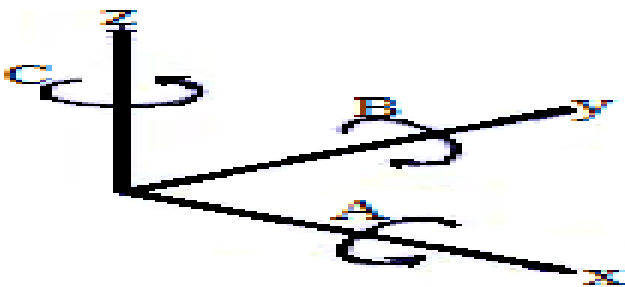


Fig. 2: The CNC axes.

#### 3.2 Stepper Driver:

Stepper motor drivers are specifically designed to drive stepper motors, which are capable of continuous rotation with precise position control, even without a feedback system. They offer adjustable current control and multiple step resolutions, and they feature built-in translators that allow a stepper motor to be controlled

with simple step and direction inputs. In this project we use two drivers for the two stepper motors.



Fig 3: Stepper driver

#### 3.3 Servo Motor:

Servo motor controls the up and down movement of drawing pen in z axis direction It controlled by sending an electrical pulse of variable width, or Pulse Width Modulation (PWM) and this can be achieved using the microcontroller. It determines the position of the shaft, through the control wire, which represent the z axis.



Fig 4: Servo motor

#### 3.4 CNC Shield:

CNC shield V 3.0 can be used as drive expansion board for engraving CNC machine. It has 4 slots in the board for stepper motor drive modules that can drive 4 stepper motors. Each stepper motor need two IO port only, that is to say, 6 IO ports can quite well to manage three stepper motors as shown in Figure 5 It is very convenient to use with the microcontroller (Arduino) such that it is placed above the Arduino.

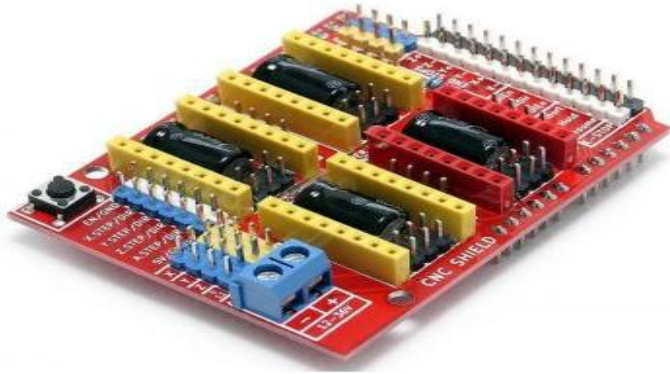


Fig 5: CNC Shield.

### 3.5 Arduino:

Arduino Microcontroller (Here Arduino Uno R3 used) controls the position of the stepper motors with the help of program instructions. This microcontroller is an open source platform based on both hardware and software that very easy to use. It has 14 digital and 6 analog input/output pins that can incorporate into various expansion boards.



Fig 6: Arduino Uno.

Here are specifications of Arduino Uno R3

PARAMETERS	SPECIFICATIONS
Micro Controller	Atmega328p
Operating voltage	5V
Input voltage(recommended)	7-12V
Input voltage(limits)	8-20V
Digital I/O pins	14
Dc current per I/O pins	40mA
Flash memory	32kb (of which 0.5 kb is used by boot loader)
SRAM	2kb
EEPROM	1kb
Clock speed	16MHz

A micro controller board, contains on board power supply USB port communicate with pc and an atmega microcontroller chip. It simplify the process of creating any control system by providing the standard board that can be programmed and connected to the system without the need to any sophisticated PCB design and implementation. It is an open source hardware, anyone can get the details of its design and modify it or make his own one himself.

### 4. ELECTRONICS SYSTEM AND WIRING:

This section will discuss the electronic parts and wiring which is needed for designing and building our CNC plotter machine. So, the main electronic component required are one Arduino UNO R3, one CNC V3 Shield with A4988 Driver Module with Heatsink for Arduino, stepper motors, D.C. power supply, pen holder, some wires and USB to serial adapter. These are some of the electronics which are needed for the wiring system.

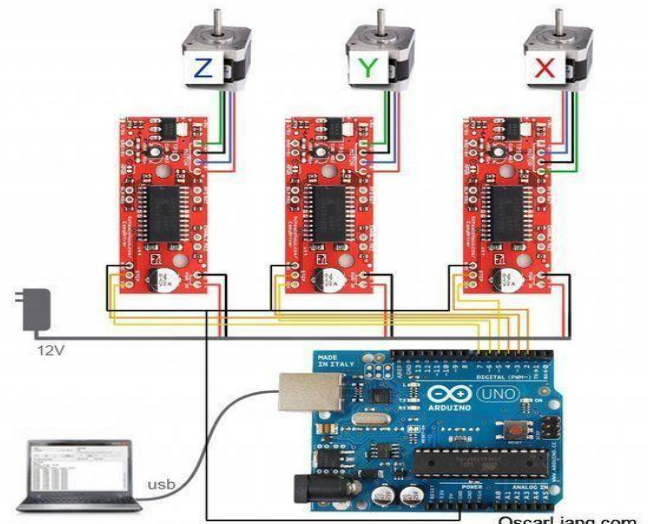


Fig 7 : Electronic system and wiring

## 5. CONNECTIONS:

The electronic connections include the connection of the stepper motor driver above the CNC shield then placing the CNC shield above the Arduino as shown in Figure 8. For simplicity two drivers were used for the two stepper motors.

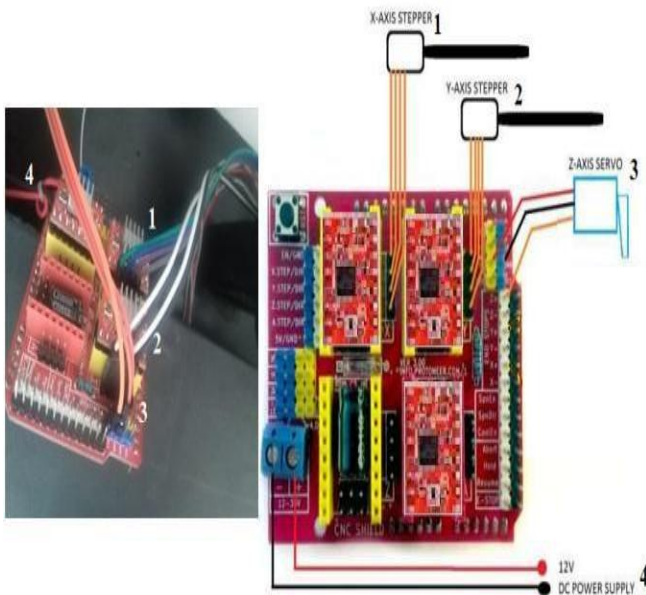


Fig 8: CONNECTIONS OF MOTORS AND POWER SUPPLY

## 6. SOFTWARE TOOLS:

### 6.1 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. Figure 9 shows Arduino software IDE

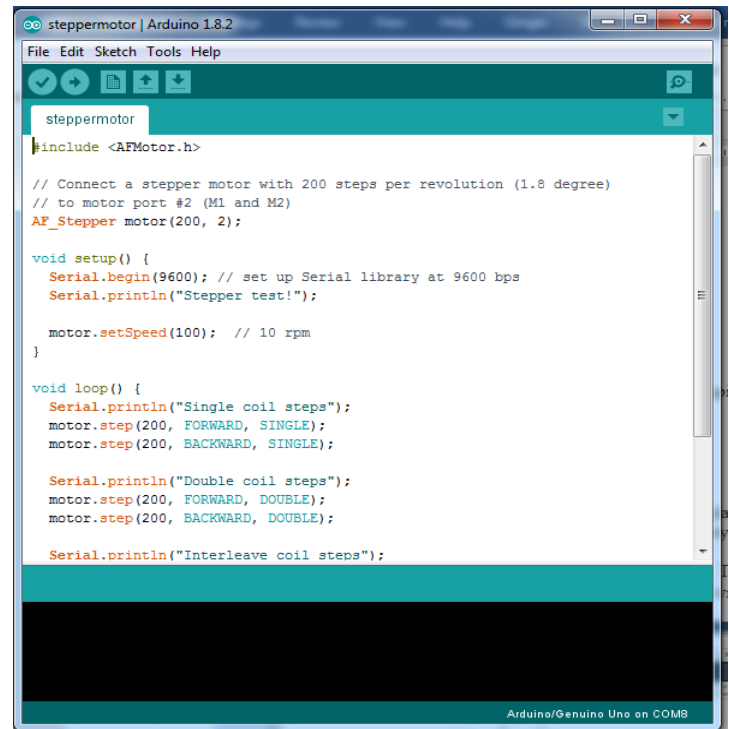


Fig 9: ARDUINO SOFTWARE (IDE)

### 6.2 Inkscape:

Using this software we can convert any image to their G code extension file. Inkscape is a free and open source vector graphics editor it can be used to create or edit vector graphics such as illustrations, diagram line, arts, charts, logos and complex paintings. Inkscape's primary vector graphics is Scalable Vector Graphics (SVG), however many other formats can be imported and exported.

Inkscape can render primitive vector shapes (e.g. rectangles, ellipses, polygon, arcs, spirals, stars and 3D boxes) and text. These object may be filled with solid colors, patterns, radial or linear color gradients and their borders may be stroked, both with adjustable transparency. Embedding and optional tracing of raster graphics is also supported, enabling the editor to create vector graphics from other photos and raster sources. Created shapes can be further manipulated with transformation, such as moving, rotating, scaling and skewing.

Using this software we can set the image size i.e 4cm x 4cm, then we create their borders and save to G code extension. After creating G code of image upload to processing software that draw our output.



Fig 10: Inkscape software

### 6.3 Creating G-Code File Using Inkscape:

The CNC plotter of our project will work within 20cm×20cm area.

So we choose the document properties of the Inkscape 40cmx40cm (Width ×Height) which is four times the working area of the plotter because the plotter can draw only in the first quadrant. So we have initially kept the axes at the nearest end of the motors which is considered as origin to easily modify the design.

The working area of CNC plotter is shown with the text written in the pre- defined area. The text is selected using cursor and then select “object to path” from the drop down window to save the G-code form of the selected text.

To create G-code of an image, the file must have a transparent background. The image should be dragged into the selected area then select trace bitmap from drop down window to create a transparent image. Scans are selected as 8 and Edge detection is selected to create black & white image. After adding this transparent image in predefined area we’ve used object to path command to create the G-code file of the selected image by following the steps described earlier.

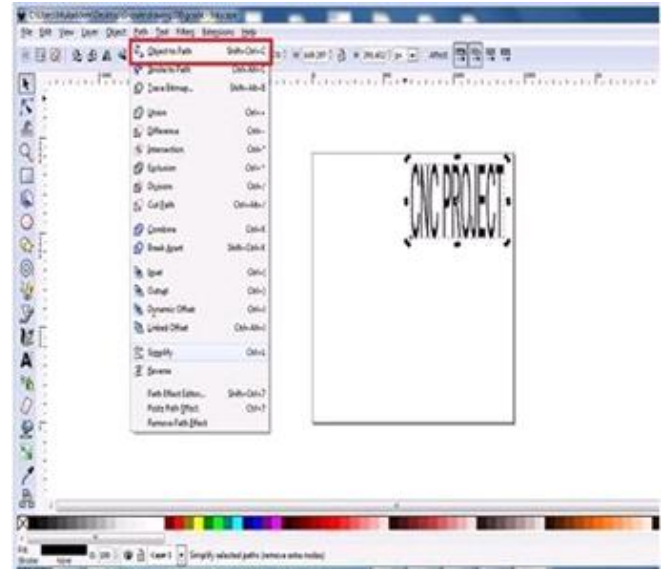


FIG 11: Conversion of Text to G Code

### 6.4 PROCESSING:

Processing is an open source software which is used for electronic drawings. GTCRL processing program is used to send G-code file from user interface to CNC plotter. The Fig. 12 shows the user interface of processing 2.2.1 software after running GTCRL program. The port of Arduino Uno is selected by pressing P button on keyboard hence „G“ button is used to upload our desired G-code file. Immediately CNC machine will start sketching selected G-code file. Sketching can be stopped by pressing X button.

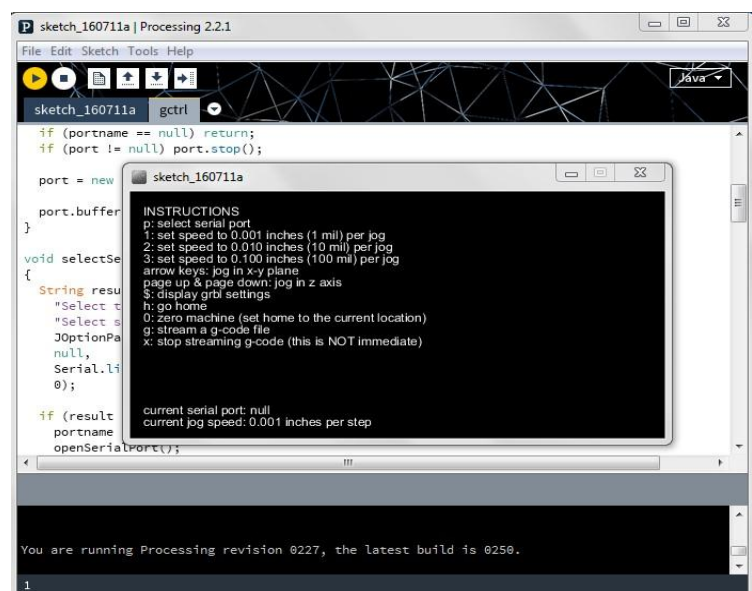


FIG 12: Processing software

## 7. CONCLUSIONS:

In this project, we used the concept of a low-cost plotter machine, which is easily controlled by the computer. It is easy to operate and the work also can be done accurate without any errors. This small machine can be easily transported and assembled everywhere as required. The board size of this device is 40X40 cm. Stepper Motor will run on this standard for board size. If we have an increase in the size or length of the lead coil, it will be free to make the large size of the design on paper. Due to small size it is restricted to a certain area width and length.

## 8. FUTURE SCOPE:

The machine is just an example of preliminary example keeping in mind the use and costs incurred. There is huge scope for further improvements in the machine. They can be listed below. It is planned to scale up the prototype CNC Machine in the terms of size, use more powerful motors, strengthen the frame and workable with the materials like aluminum or cast iron, and augment the CNC control software for stimulation ahead of actual run. The implementation of 3D printing technology can also be done to the same hardware for printing of 3d models.

## 9. REFERENCES:

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## BIOGRAPHIES:

### 1<sup>st</sup> Author : SYED FAZLE HYDER



He is pursuing B. tech final year in Mechanical Engineering from Nawab Shah Alam Khan college of Engineering and Technology (JNTUH) Telangana, India & recognized by AICTE, accredited by NAAC. He has completed his intermediate from Sri Chaitanya Junior Kalasala Narayanaguda, Hyderabad.



### 2<sup>nd</sup> Author: MOHAMMED IBRAHIM

He is pursuing B.tech final year In Mechanical Engineering from Nawab Shah Alam Khan college of Engineering and Technology (JNTUH) Telangana, India & recognized by AICTE, accredited by NAAC. He has completed his intermediate

from Sri Chaitanya junior kalasala Narayanaguda, Hyderabad



### 3<sup>rd</sup> Author: MOHAMMED ZEESHAN ADAN

He is pursuing B tech final year in Mechanical Engineering from Nawab Shah Alam Khan college of Engineering and Technology (JNTUH) Telangana, India & recognized by AICTE, accredited by NAAC. He has

completed his intermediate from SR Junior College, Malakpet, and Hyderabad.



### 4<sup>th</sup> Author: FAZAL MOHAMMED

He is working as an assistant professor department of Mechanical engineering in Nawab Shah Alam Khan College of Engineering and Technology from 5 years. Done M. Tech in machine design from VTU regional center Gulbarga, and B.E in mechanical engineering

from Poojya Doddappa Appa College of Engineering Gulbarga,