

# Design and Implementation of CNC Router

M.Bhavani<sup>1</sup>, V.Jerome<sup>2</sup>, P.Lenin Raja<sup>2</sup>, B.Vignesh<sup>2</sup>, D.Vignesh<sup>2</sup>

Assistant Professor, Department of Mechanical Engineering, New Prince Shri Bhavani College of Engg and Tech,  
Chennai, Tamil nadu, India

UG Student, Department Mechanical Engineering, New Prince Shri Bhavani College of Engg and Tech,  
Chennai, Tamil nadu, India

**ABSTRACT:** A CNC router is very similar concept of CNC milling machine. In this tool paths are controlled via computer numerical control. The aim of this project is used to reduce cost and complexity of machine. This project deals with the design of automatic CNC machine for PCB drawing and drilling, wood engraving and cutting, glass cutting. This work is concerned with the design and development of Control unit comprising of the Arduino as the core element in controlling the motion in X, Y and Z direction of the Computer Numerical Control machine. Three unipolar stepper motors are used for controlling the machine axes.

**KEYWORDS:** Computer Numerical Control (CNC), Printed Circuit Board (PCB), G-code

## I. INTRODUCTION

Computer Numeric Control (CNC) is the automation of machine tools that are operated by precisely programmed commands encoded on a storage medium (computer command module, usually located on the device) as opposed to controlled manually by hand wheels or levers, or mechanically automated by cams alone. Most NC today is computer (or computerized) numerical control (CNC), in which computers play an integral part of the control. In modern CNC systems, end-to-end component design is highly automated using computer-aided design (CAD) and computer-aided manufacturing (CAM) programs. The programs produce a computer file that is interpreted to extract the commands needed to operate a particular machine by use of a post processor, and then loaded into the CNC machines for production. Since any particular component might require the use of a number of different tools – drills, saws, etc. In Computer Numeric Control (CNC), microprocessor is used which is capable of processing logical instructions interfaced with a computer. The logical instructions are provided by using a computer in the form of code or text or image which is then transformed into a machine language by microprocessor to be executed by the machine.

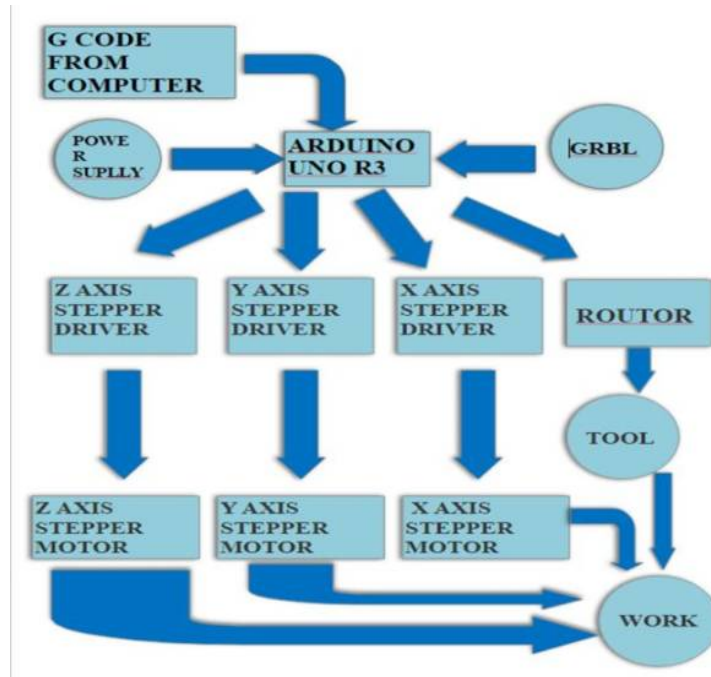
Mini CNCs are much smaller in size and affordable. With much smaller space CNCs can be used by normal people for domestic issues. Here it is tried to develop CNC technology to make it more portable and up gradable to 3D Printer for smaller issues with much less power

## II. OBJECTIVES

The main objective of this project to develop a low cost automatic mini CNC machine for PCB drawing and drilling, wood engraving and glass cutting. This system reduces the cost of machine and increases the flexibility

## III. METHODOLOGY

The G code is interfaced with Arduino CNC based controller by GRBL module which is used to convert the code in convenient controller code i.e serial to USB converter. Hence it acts like interfacing module between PC to Controller. This code is further passed to stepper motor by easy drivers which converts the code and as per instructions the stepper motor moves. We need three axis X,Y,Z which operates as follows X stepper motor move left and right Y stepper motor moves front and back and Z stepper motor up and down as per given dimensions these axis's will move on..



#### IV. MECHANICALSETUP

##### Design

A CNC could be designed various ways. One of them are fixed router with movable bed type and another type of design is with 3axis router movement what we have used here. A computer aided design was created first to analyse

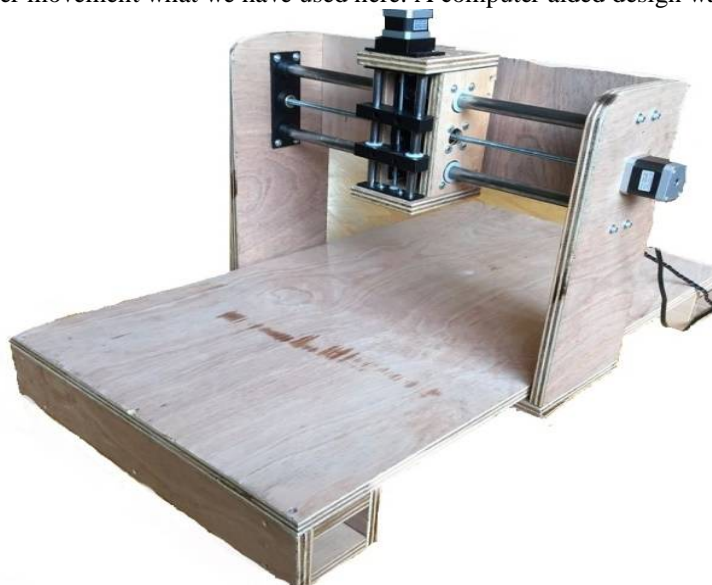


Fig.1: Actual design of cnc

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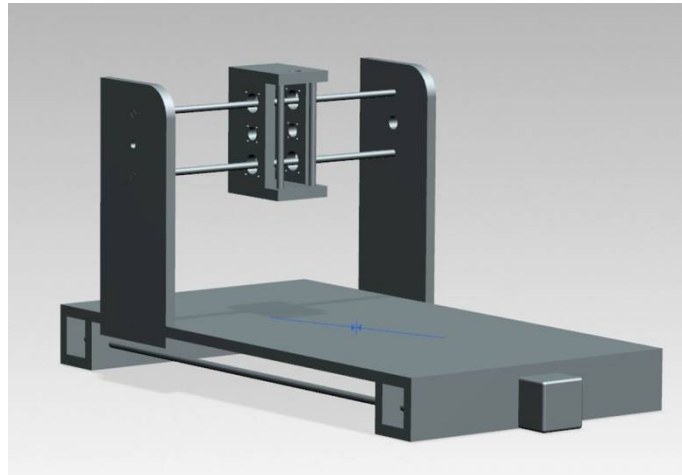


Fig.2: Basic CAD design of cnc

## V. COMPONENTS

### Stepper motor & Accessories:

It's a combination of stepper motor drive connected with GT2 pulley with Grub screw that is mechanical linear bar and linear bearings that drives rotational motion into linear motion with minimum friction. Traveling bar dimension 4mm X 250 mm for Y-Axis and 3 mm X 184 mm for X-Axis. Geared Stepper Motor with 1:30, 12V. The stepper motor as represented in Fig. 2 have 1/30 step angle and the speed is directly proportional to the pulse frequency where it stands of the higher the output voltage from the easy driver the more level of torque drive. Microcontroller Board: Uno r3 it's an Arduino Board it's selected to be the control unit in this project, which it's used as a motion control board. The Arduino Uno is a microcontroller board based on the ATmega328 as shown in Fig. 3. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.



Fig 3:stepper motor

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## Power Supply:

12V SMPS (Switch mode Power Supply) is used for stepper motor driver. 2V SMPS is used to power the microcontroller board (Arduino Uno3). The microcontroller is flashed with GCODE interpreter firmware written in optimized 'C' language.



Fig 4:Arduino

## Stepper Motor Drivers:

It's kind of driver that receive steps signal from microcontroller and convert it into voltage electrical signals that turn the motor. This driver is called l298n Driver V4.5 as shown in Figure.5 that required 6V – 30V supply to power the motor which can power any type of step motor.

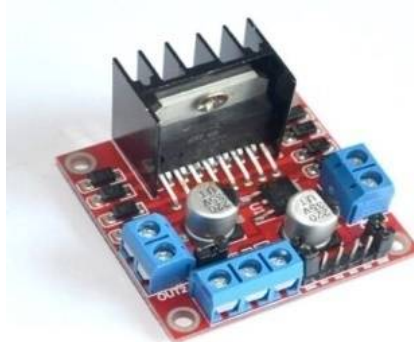


Fig 5:l298n

## VI. SOFTWARE DEVELOPMENT

The CNC machine uses Grbl v0.9 software which is shown in Figure.6 for motion control of the axis. Grbl converts G-code into certain commands that Easy driver stepper motor will understand. Also required another program to send the G-code to Grbl.

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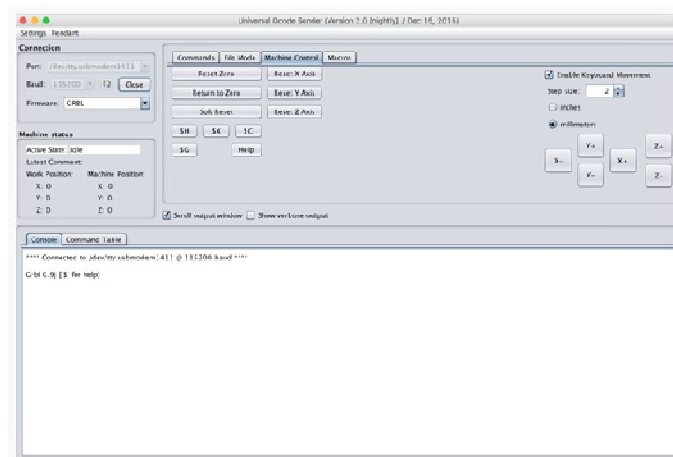


Fig 6 Universal G-code sender

```
Grbl 0.9j ['$' for help]
$0=10 (step pulse, usec)
$1=1 (step idle delay, msec)
$2=0 (step port invert mask:00000000)
$3=7 (dir port invert mask:00000111)
$4=0 (step enable invert, bool)
$5=0 (limit pins invert, bool)
$6=0 (probe pin invert, bool)
$10=3 (status report mask:00000011)
$11=0.010 (junction deviation, mm)
$12=0.002 (arc tolerance, mm)
$13=0 (report inches, bool)
$20=0 (soft limits, bool)
$21=0 (hard limits, bool)
$22=0 (homing cycle, bool)
$23=0 (homing dir invert mask:00000000)
$24=25.000 (homing feed, mm/min)
$25=500.000 (homing seek, mm/min)
$26=250 (homing debounce, msec)
$27=1.000 (homing pull-off, mm)
$100=1280.000 (x, step/mm)
$101=1280.000 (y, step/mm)
$102=250.000 (z, step/mm)
$110=500.000 (x max rate, mm/min)
$111=500.000 (y max rate, mm/min)
$112=100.000 (z max rate, mm/min)
$120=20.000 (x accel, mm/sec^2)
$121=25.000 (y accel, mm/sec^2)
$122=10.000 (z accel, mm/sec^2)
$130=200.000 (x max travel, mm)
$131=200.000 (y max travel, mm)
$132=200.000 (z max travel, mm)
ok
ok
```

Fig 7 program

In order to begin programming it's required for IDE Arduino software shown in Fig. 7.

To make it easier and friendlier to generate G-code the best way is to use "Inkscape" combined with laser engraver plug-in which is an open source graphical editor.

## VII. CIRCUIT CONNECTIONS

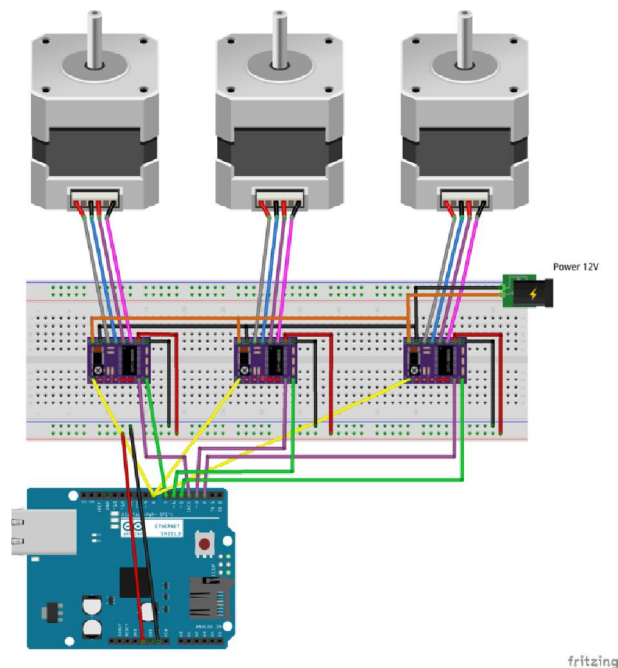


Fig 8 circuit connections

## VIII. ALGORITHM

### Software Algorithm:

1. Converts JPEG/BMP format image into binary code that is string of 1's and 0's in to rows (I) and columns (J).
2. The binary code is again converted to ASCII like code which is suitable for Serial communication.
3. Then code is sent to the microcontroller via serial port of PC (personal computer) .

### Microcontroller algorithm:

1. Waits for the serial data to come from PC.
2. If the binary data is of a row then the microcontroller controls horizontal (x-axis) stepper- motor in forward direction. If the row data is binary '1' it controls the Z-axis motor for plotting along with X-motor else if data is '0' it only controls X-motor.
3. If the data of a row is over then it controls the Vertical(y- axis) stepper motor (Moves to next line) before that it retracts the X-axis motor.
4. The microcontroller acknowledges by sending an acknowledgement signal to PC after receiving data from it.
5. This operation repeats until all rows are over that is if all bits are over then the Y- axis goes to initial position and microcontroller waits for next data to come.

## IX. SPECIFICATION

Working area x,y,z	: $(\pm 40) \times (\pm 70) \times (\pm 10)$ mm
Table size	: 550x920mm
Microcontroller	: Arduino uno R3
Drivers	: L298n
Command	: G code

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Work holding	: by clamp
Motors	: stepper motor (nema 17)
X,y,z transmission mode	: threaded rod linear motion
Spindle	: 300w
Spindle speed	: 30000rpm
Diameter of cutter	: 3mm – 10mm

## X. FUTURESCOPE

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.

## XI. CONCLUSION

This project is about building a mechanical prototype of a CNC ROUTER which is able to draw a PCB layout and Wood engraving. 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.

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