Post Graduate Diploma In Industrial Robotics

PROJECT REPORT

ON

"Arduino Based CNC Drilling Machine"

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CERTIFICATE

Certified that this project report **"ARDUINO BASED CNC PCB DRILLING MACHINE"** is the bonafide work of "**Nikhil Bhomle, Aniruddha khandekar, Yash Gangotri"** who carried out the project work under my supervision in partial fulfillment of the requirements for the award of the diploma of Post graduation diploma in **Industrial Robotics of Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur.**

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ACKNOWLEDGEMENT

Here we are presenting our project titled

“ARDUINO BASED CNC PCB DRILLING MACHINE”

The success and final outcomes of this project required valuable guidance and assistance from many people. We are thankful to our Project Guide and Head of the Department **Mr. Sandip Sonaskar** for his guidance, beginning from the selection of project topic and up to the completion of the project, he helped us thoroughly and was ready to help us every time.

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We are grateful to the Management, Principal to all teaching and non teaching staff of Industrial Robotics Department for providing us the Infrastructure and the other necessary facilities to complete the project. Last but not the least we would like to express our gratitude to our friends and respondents for their support and willingness to spend some time with us to fill in the questionnaires.

ABSTRACT

The scope of this project was to design and fabrication of drilling machine which focus on the main operation i.e., drilling. The project began with the collection of information and data on user lifestyle and current process by which they perform their job. The Concepts was developed with reference of different types of milling machine and their different operating processes. The project was developed considering the safety factor user operating environment and maintenance. Considering the users need and buying capacity, this prototype was fabricated. The machine consists of Lead Screw, Motor Driver, Stepper Motor, Arduino, Spindle Motor and Aluminum Extrusion Frame.

In this project, the position of the drill hole and milling operation is taken by the developed software. Then it calculates the previous and current co-ordinate and sends the coordinate information Micro-controller unit over USB cable. Stepper motors move on the basis of co-ordinate information to accomplish the drilling of PCB

Due to the rapid growth of technology the usage & utilization of CNC machine in industries are increased. The fabrication of low-cost CNC machine is used to reduce cost and complexity of machine. This project deals with the design of automatic CNC machine for PCB drilling. The Idea behind our project is to design and drill PCB based on low-cost CNC system the lower cost is achieved by incorporating features of PC with ATMEGA 328 controller in an Arduino. We have used an G code for whole system operation G code is nothing but a language in which people tell computerized machine tools 'How to make something'. The How is defined by instructions on where to move & how fast to move

Key Words: Drilling machine, Arduino, Axis, Printed Circuit Board (PCB), UGS Software, Flat CAM.

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CHAPTER 1

INTRODUCTION

CHAPTER 1

INTRODUCTION

1.1 OBJECTIVES OF THE PROJECT

To develop a low-cost automatic CNC machine for PCB drawing and drilling. This system reduces the cost of machine and increases the flexibility.

The idea behind fabrication of low-cost CNC Milling Machine is to full fill the demand of CNC machines from small scale to large scale industries with optimized low cost. A major new development in computer technology is the availability of low-cost open-source hardware, such as the Arduino microcontroller. An advantage of open-source hardware is that a wide variety of ready-to-use software is available for them on the Web; therefore, the prototyping and development times are drastically reduced. Moreover, a wide range of low-cost interfaces and accessories such as Mach3 CNC control software are also available. However, for the development of low-cost models of CNC machines, such tools may be quite adequate from the viewpoint of machine control. In this project, the development of a prototype 3-axis CNC Milling Machine is presented with the following specification.

- Easily operable
- Easy interface
- Flexible
- Low power consumption

PCB stands for Printed Circuit Boards which helps in connecting the electronics components with pads, line, tracks incorporated on a laminated copper sheet. This method was costly and complicated in design. To reduce the time and to make design simple this method was introduced. This was the revolution in the electronics industry with the lots of productivity and innovative ideas. Once you set all the parameter required, the machine will start working without any human interfere so we can call it as automation. Arduino based 3 axis PCB milling and drilling machine is inspired form today's technology revolutionary change in the world of electronics and microcontrollers. On basis of PCB drilling machine, the stepper motors are interfaced to the Arduino controller. The stepper motors are used to move plate of PCB in X, Y and Z direction.

NEED OF PCB

In all the electronics devices printed circuit boards is very important either it is used for domestic purpose or for industrial purpose. PCB design service are used to design electronic circuit. Apart from electrically connecting it also gives mechanical support to the electrical components. The design of PCB can be created both manually or automatically. With the help of CAD drafting manual layout are created and the automatic router helps in creation of design automatically. Since they can implement their own ideas and technique the designer usually prefers the manual way.

PCBs are commonly composed of composite material, composite epoxy, and fiber glasses.
In the electronics devices these are the most common components used which makes the design compact and sophisticated. PCBs are provided with different layers and multiple design. In some of the electronics device's PCBs are composed of single layer. Some of the most common hardware such as motherboard and graphic card multilayer PCBs are used. PCBs are widely used advanced electronic devices such as cameras, led, etc. as they are not associated with computers only. To increase the production rate with greater percent This can be the new invention in the electronics industries.

1.2 WHAT IS CNC?

CNC machines are making parts around the world for almost every industry. They create things out of plastics, metals, aluminum, wood and many other hard materials. The word “CNC” stands for Computer Numerical Control, but today everyone calls it CNC. So, how do you define a CNC machine? All automated motion control machines have three primary components – a command function, a drive/motion system, and feedback system. CNC machining is the process of using a computer-driven machine tool to produce a part out of solid material in a different shape

The CNC depends on digital instructions usually made on Computer Aided Manufacturing (CAM) or Computer Aided Design (CAD) software like SolidWorks or MasterCAM. The software writes G-code that the controller on the CNC machine can read. The computer program on the controller interprets the design and moves cutting tools and/or the workpiece on multiple axes to cut the desired shape from the workpiece. The automated cutting process is much faster and more accurate than a manual movement of tools and workpieces which is done with levers and gears on older equipment. Modern-day CNC machines hold multiple tools and make many types of cuts. The number of planes of movement (axes) and the number and types of tools that the machine can access automatically during the machining process determine how complex a workpiece a CNC can make.

1.2.1 Applications of CNC

- Electronics Industry
- Military and Defense Industry
- Healthcare Industry
- Marine Industry
- Automotive Industry

ELECTRONICS INDUSTRY

As in the case of the automotive industry, the electronics industry uses CNC machining in prototyping and the production stage. An advantage CNC machining offers in electronics is the ability to handle small-scale construction with consistency

MILITARY AND DEFENCE INDUSTRY

The optimization and data analysis of IoT helps the consumers personally and professionally. A personal assistant, advisor and security is provided by IoT technology by enhancing the manner in which consumers live, work and play.

HEALTHCARE INDUSTRY

It may seem surprising to know that CNC systems are used in the healthcare sector. However, the applications of CNC machining in healthcare are extensive. CNC machining in the healthcare and medical industry is used for manufacturing medical supplies and rapid tooling to create dies for injection molding. Then, the injection molding process produces equipment like face masks.

MARINE INDUSTRY

The marine industry relies on high-quality craftsmanship since it creates water transportation that might travel all over the globe. The large-scale manufacturing process for boats and other water transportation requires automation to fulfill the manufacturing deadlines and quality control. This is only possible with CNC machining.

AUTOMOTIVE INDUSTRY

The automotive industry is one of the main sectors for CNC machining. CNC machining offers advantages at every stage of the automotive manufacturing process, from prototyping in Research and Development (R&D) to producing large quantities of parts.

In addition, CNC milling machines and lathes make a lot of different components, from large engine block parts to small gears and panels. These machines work on plastics as well as metals in automotive industries.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Following are the journal papers reviewed and studied for the project automatic PCB drilling machine In first paper entitled “Automatic PCB Drilling Machine “ by Mr. S. V. Vanmore1, Miss. Snehal S. Katkar2, Miss. Uttkarsha A. Kasar3, Miss. Prachi P Bhosale4 , Volume: 03 Issue: 03 | Mar-2016 includes the importance and benefits of the automatic PCB drilling machine. Also it describes the method of X,Y,Z axis. The machine designed based on co-ordinate measurement machine, therefore the machines have designed with three coordinate, X, Y and Z. it also showed the hardware design of the automatic PCB drilling machine. It shows that the path planning algorithm optimizes the use of the motors and other mechanical paths involved in the process while reducing total time taken to cross all the drill holes.[1] In the second journal entitled “Automated printed circuit board (PCB) drilling machine with efficient path planning ‘’ includes the study on the efficient path planning of the machine.

This paper presents the design of a PCB drilling machine, where the drill holes are automatically detected from an image of the circuit eliminating the need to manually enter the drill hole coordinates. Further, the drilling machine uses a path planning algorithm, which is capable of estimating an efficient traversing path for the drill bit minimizing the length of travel. Here in this study the image processing is used drastically to get the data of the coordinates of the PCB design layout. It also has a row-by-row scanning method. The TSP algorithm is used for the efficient path finding. It tells that a simple drill hole map can be successfully used to obtain the coordinates needed to perform an automated drilling operation. [2] In the third journal paper entitled “An Experimental Study of the Application of Gravitational Search Algorithm in Solving Route Optimization Problem for Holes Drilling Process “International Conference Recent treads in Engineering & Technology (ICRET’2014) Feb 13-14, 2014 Batam (Indonesia) incudes the study of the Route Optimization Algorithm. In this study, an optimization algorithm based on Gravitational Search Algorithm is proposed for solving route optimization in holes drilling process. The proposed approach involves modeling and simulation of Gravitational Search Algorithm. In this study, the proposed approach that is GSA is implementing to find the optimized path for PCB

holes drilling process. It is a simple method and easy to implement to find the best route for holes drilling process. The result collected by this paper clearly shows that the proposed approach performs better. The problem formulation is given in this paper. Also "MODELING ROUTE OPTIMIZATION IN HOLES DRILLING PROCESS USING GRAVITATIONAL SEARCHALGORITHM" is the important thing throughout the journal paper.

The paper is mostly related to the path planning.[3]

CONCEPTS

The main tools used in the mechanical design consist of work board which is of aluminum extrusion, smooth rods lead screw, angle joints, stepper motor, ball bearing, support stands, anti-backlash nuts. The PCB is placed in the system then it is drilled automatically through path planning. By the PCB design software, it generates the coordinate in x, y, z direction. A high amount of current is passed in order to drive the motor exactly. There is another method which uses microcontroller c programming. To control the drill the system is consist of 3 stepper motor. The path planning method is not used in this project. The automatic PCB drilling machine uses a path planning algorithm, which locate the exact traversing path for the drill bit to move. In this project, the position of the drill hole is taken by the developed software. Then it calculates the previous and current co-ordinate and sends the coordinate information Micro-controller unit over USB cable. Stepper motors move on the basis of co-ordinate information to accomplish the drilling of the PCB.

2.2 PAST RESEARCH

2.2.1 Manish Patil, Prof. Hredeya Mishra published a paper under a title (Literature review for designing a portable CNC machine) in journal International Journal for Innovative Research in Science & Technology.

they discussed literature review of different authors who were tried to make CNC machine. They said that CNC machines are main reasons in the contribution of good quality products in industries.

2.2.2 R.Ginting, S. Hadiyoso and S.Aulia published a paper under a title (Implementation 3Axis CNC router for small scale industry) in journal International Journal of Applied Engineering Research

In which they have realize the complex of 3 axis CNC machine which is based on microcontroller which is combined with spindle drill which can be used for cutting, engraving. Which can give more carving accuracy and more engraving accuracy.

2.2.3 Rajesh Kannan Megalingam, Shree Rajesh Raagul Vadivel, Sreekumar S, Swathi Sekhar, Thejus R Nair, Midhun RR published a paper under a title (Design and implementation of CNC milling bot for milled circuit board fabrication) in journal International Journal of Engineering &Technology

In this paper they purpose a computer control milling machine which would be used for fabrication of double layer PCBs which are called as MCBs where the user can test the circuit without the need waiting of conventional PCB fabrication.

CONCLUSION

As per the literature survey done there are much more areas improved by defining problems in PCB drilling machine related to various factors. It provides the information related to survey on CNC, also implemented the low-cost CNC system for obtaining the defected solar panels and finally we designed, developed, and trial work performance of Arduino based PCB drilling CNC Machine.

CHAPTER 3

COMPONENTS DESCRIPTION

CHAPTER 3

COMPONENTS DESCRIPTION

3.1 INTRODUCTION

In this Arduino based PCB drilling CNC machine, we are using the following components: Arduino UNO, Linear bearing, Lead Screw, CNC Shield, Aluminium frame, Motor driver. The main purpose of using all these components is to get the value of voltage and current. For voltage we are using a voltage sensor and for current we are using a current sensor. Solar panel is used to get electrical energy. For displaying this data in the Blynk app we are using ESP32. In this chapter we will study all the components in depth to understand how they work.

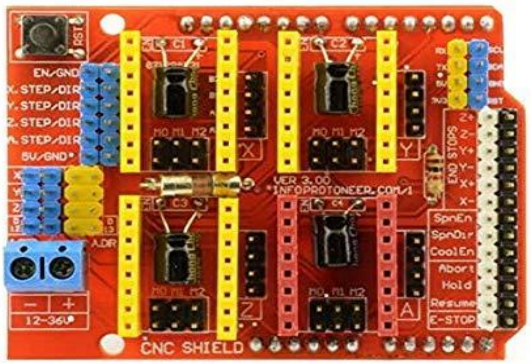
3.2 COMPONENTS

Fig 3.2.1: Arduino UNO

3.2.1 ARDUINO UNO:

Arduino Uno is a microcontroller board dependent on ATmega328. Its working voltage is +5V. it comprises of 14 advanced I/o pins. It can withstand input voltage from 7-20 V. The DC Current per pin 40ma. It has 32kb of glimmer memory. It working default clock recurrence is 16MHz.

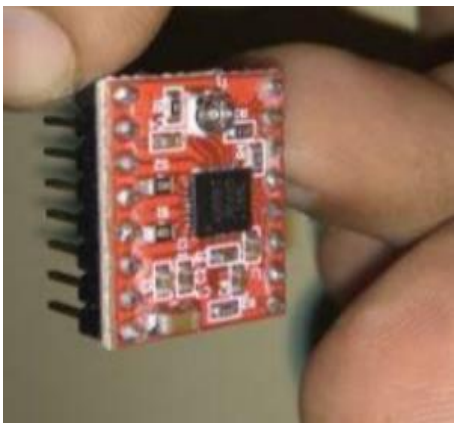
3.2.2 CNC Shield:



The CNC Shield V3. 0 allows to build a drilling machine, 3D printer, mini CNC and other similar devices using Arduino. It is designed as a shield and can plug on top of an Arduino requiring no external connections and wiring.

Fig 3.2.2 CNC Shield

3.2.3 Motor Driver:



The motor driver is a module for motors that allows you to control the working speed and direction of two motors simultaneously. This motor driver is designed and developed based on L293D IC. L293D is a 16-pin motor driver IC. This is designed to provide bidirectional drive currents at voltages from 5v to 36v.

Fig 3.2.3: Motor Drive

3.2.4 LINEAR BEARING: The LM8UU 8 MM Linear Motion Bearing gives very precise, safe and reliable linear motion system. Such linear motion bearings are mostly used in **3D printers** and CNC (Computer Numerical Control) machines. An LM8UU 8 MM Linear Motion Bearing can provide low friction motion along a single axis.

This LM8UU 8 MM Linear Motion Bearing closed type ball bushing has an 8mm bore and 15mm outer diameter is suitable for use in a mounted slide unit to carry components. .

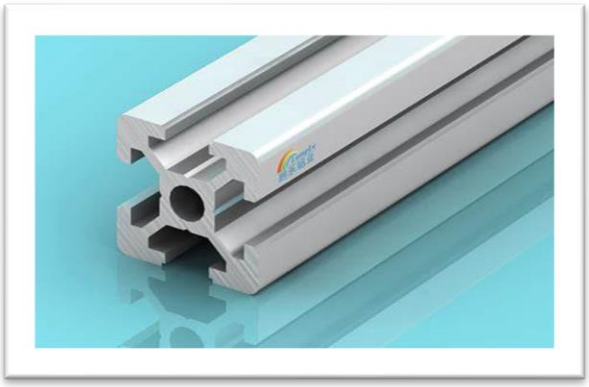
Fig 3.2.4 Linear Bearing

3.2.5COUPLER: Aluminum Flexible Shaft Coupling is lightweight coupling and exhibits more strength in class. This is made up of HE-30 grade aluminum. This type of couplings is very common and found in a wide range of CNC Machines. They can firmly hold the shaft of the motor and other peripherals with the help of Grub Screws which can be tightened rigidly by using Allen Key.

Bore diameter : 8mm

Fig 3.2.5 Coupler

3.2.6 ALUMINUM PROFILLE:



We used Aluminum Extrusions Aluminum Profiles Frame for milling and drilling Machine. Which reduces the cost and have good durability.

Fig 3.2.6 Aluminum Profile

3.2.7 BEARING: 608RS Rubber Sealed Ball Bearing Miniature Bearing 8 x 22 x 7 mm is used in this project

This bearing comes in shielded version, where RS stands for rubber sealed bearing. It has deep groove geometry for supporting both radial and axial loads and high speeds.

Fig 3.2.7 Bearing

3.2.8 SPINDLE MOTOR:

The CNC spindle is the heart of any mill. It consists of a rotating assembly with a taper where tool holders may be installed. A spindle motor with optional transmission of some kind rotates the CNC spindle. The transmission matches the highest power rpm range of the CNC spindle motor to the spindle rpms that are ideal for the particular speeds and feeds of the material being cut

Fig 3.2.8: Spindle Moto

3.2.8 LEAD SCREW:

Leadscrews are commonly used in linear actuators, machine slides (such as in machine tools). Leadscrews are a key component in electric linear actuators. A lead screw turns rotary motion into linear motion combining a screw and a nut where the screw thread is in direct contact with the nut thread

Fig 3.2.9: Lead Screw

3.2.9. Stepper Motor

3.2 CONCLUSION

In this project we have studied the detailed working of all the components used in this Arduino based CNC PCB drilling machine. We understand the concept, working principle of all the components and their uses.

CHAPTER 4

DESIGN OF PROPOSED SYSTEM

CHAPTER 4

DESIGN OF PROPOSED SYSTEM

INTRODUTION

In this chapter we will learn how the solar power monitoring system using IOT works as well as their advantages. This chapter is based on the working and circuit connection of the project. This chapter gives us the circuit designing idea and also, we understand how to monitor current value and voltage value. In this chapter we also learn the Internet of things and their uses. For that we are using some coding part that is put in the controller. The coding is done in C++ language using Visual Studio code as a compiler to compile the code. Coding is done to get the data of voltage sensor and current sensor and show it on LCD and Blynk app.

This project has been classified into the following modules for successful execution:

- Mechanical System
- Electronics and Control System
- Software System

How this system works is quite a simple procedure. The machine operator inputs the G and M code into the GUI (Graphic User Interface) which then sends the G and M code to the software which interprets the code and sends the signals to the electronic driver. The driver then runs the motors which are connected to the lead screws that are responsible for the movement of the tool.

4.1 MECHANICAL SYSTEM:

The mechanical system is assembled in such a way that the 3-axis movement is achieved by using the linear bearings and guide rods. Stepper motors are mounted to each axis which is the source of motion acted according to the control signal generated from the electronics circuit. Each stepper motor is coupled to the screw rod which carries nut with the help of coupling bush. This screw rod and nut arrangement is responsible for converting the rotational motion of the stepper motor to linear motion. The linear motion of each axis is carried away smoothly by the linear bearing and guide

rod assembly connected to the each axis which is capable of load carriers and allows linear motion in each axis. The controlled motion in each axis is achieved directly by controlling the rotation of the stepper motor. The speed of the motion in each axis can also be controlled by direct control of the speed of the stepper motor by giving required control signals. Thus the tool path of the spindle fixed to the end effector is controlled in each axis for smooth carving or cutting action of work piece.

The principle tools used in the mechanical design consist of work board which is of aluminum extrusion, smooth rods, lead screw, angle joints, stepper motor, ball bearing, support stands, anti-backlash nuts. The PCB is placed in the system then it is drilled automatically through path planning. By the PCB design software, it generates the coordinate in x, y, z direction. To control the drill the system is consist of 3 stepper motor. The automatic PCB drilling machine uses a path planning algorithm, which locate the exact travelling path for the tool to move. In this project, the position of the drill hole and milling operation is taken by the developed software. Then it calculates the previous and current co-ordinate and sends the coordinate information Micro-controller unit over USB cable. Stepper motors move on the basis of co-ordinate information to accomplish the drilling and milling of the PCB.

Metal Frame:

Metal framing is the skeleton of a building. It provides the framework for interior layout, ensures proper spacing of interior areas, is one of the first steps to any refurbishing or reconstruction project, and is essential to creating a space that is not only functional, appealing as well.

Dimension: 500*390*360

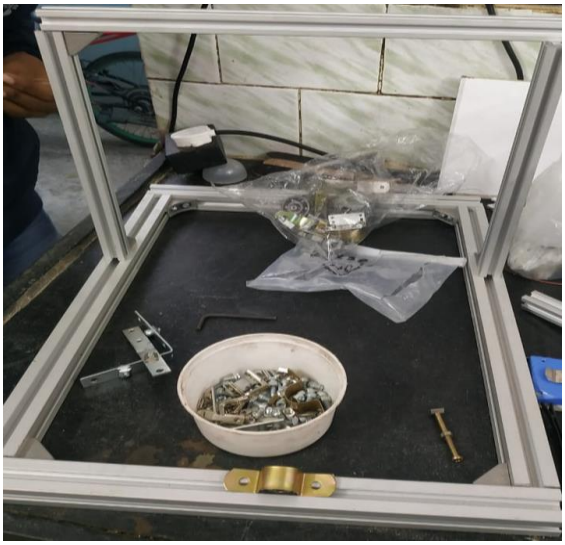


Figure 4.1: Metal Frame work

4.2 ELECTRICAL SYSTEM:

Electronics system comprises of:

- Power supply
- Arduino Microcontroller board
- Stepper motor driver board

Power Supply

Power supply is heart of the CNC system which converts the AC voltage to DC voltage and supplies required voltages to the corresponding devices. Microcontroller board operates at5v supply whereas the stepper motor board operates at 12v.

Stepper Motor Driver Board

For smooth and quiet operation is chosen to drive the NEMA 17 stepper motor. Stepper motor Driver Board receives 14 the control signal from the microcontroller board to the terminals PULSE and DIR which generates the corresponding digital pulse signals for stepper motor to control the rotation of the motor.

4.3 SOFTWARE SYSTEM:

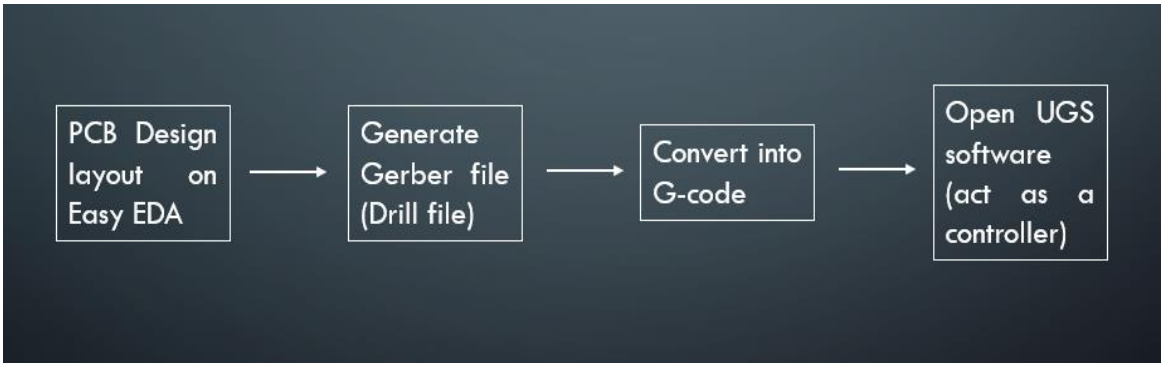
The machine designed based on co-ordinate measurement machine, therefore the machines have designed with three coordinate, X, Y and Z. The PCB is moved along the X and Y axis and Z co-ordinate are used to move the tool up and down. We are using easy EDA software which is an open-source software to provide design to PCB. Then the file is transferred to the flatCAM software which is basically G-code converter. It converts design of PCB in G codes. Pc is connected to Arduino uno with USB cable. It is connected to the GRBL controller which control the motion of machines. Which gives the motion to stepper motor which are connected in 3 different axes. As per the command received from the software 3 motors work in 3 axes individually or with each other. According to the motor our whole assembly works as workbench moves along Y-axis, spindle motor moves along Z-axis, and the motor assembly moves along X-axis

The software tool chain of CNC-based manufacturing is represented in the fig 1. The part to be machined is designed in computer-aided design (CAD) software, format. This

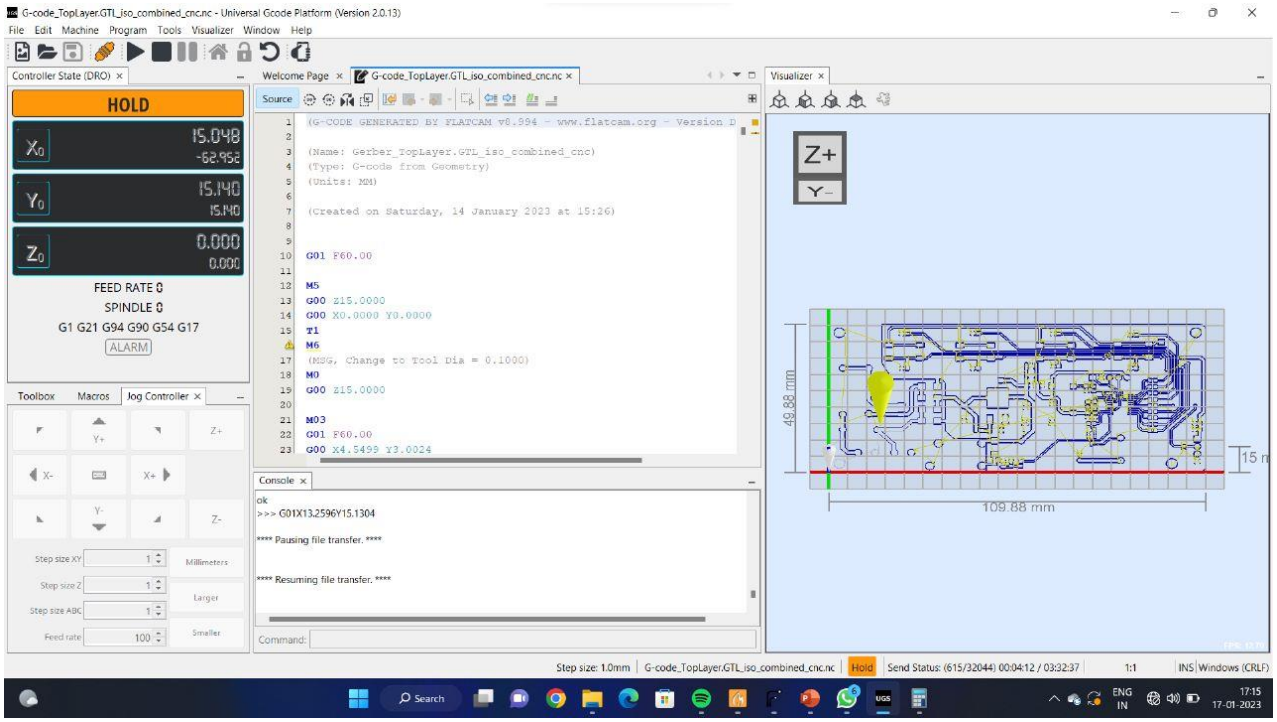
drawing is then fed to the computer-aided manufacturing (CAM) software, whose output is the machine-readable code used for numerical control of the machine. Since implementation of the G code is machine dependent,

For keeping software development costs low, we decided on using an off-the-shelf software for the more rigorous PC-to-microcontroller backend processing while developing a customized and bespoke front-end Human-Computer Interface (HCI) ourselves. Since both of these software packages would have to communicate with each other flawlessly, we have to ensure compatibility.

Work flow Overview:



PCB is designed on easyEDA software and the gerber file is opened into the flatCAM software where gerber file is converted into the G code for drilling and milling purpose, afterword by opening UGS (Universal G code Sender) g code is uploaded into the Arduino CNC shield.



The package chosen for the backend system was USG(Universal G-code Sender) developed by Newfangled The main reason this was chose is because of its free-ware as well as open-source nature. Being freeware meant that it quite literally didn't cost us at all to use this software. Due to being open-source, we have access to its source code, which we interpreted and learned and then streamlined to adapt to our machine's functions and hardware. In its original form the code was approximately 5200 lines of code written in the C++ programming language. After streamlining and removing irrelevant functions pertaining to milling, we brought the code down to only about 1800, lines of code which included only our desired command set for milling and drilling machine operations.

4.4CONCLUSION

In this chapter we studied the design of Arduino based CNC PCB drilling machine We understand the concept of integration of both hardware and software together. Also learned the G code software used for Arduino based CNC PCB drilling machine.

CHAPTER 5

CONCLUSION & FUTURE SCOPE

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5.1CONCLUSION

This project will display the advancement of a minimal effort PCB milling and drilling machine. As it is coordinated effort of both equipment and programming the remaining task at hand decreases. G-codes is used to plot the area effectively. Making a little machine will create PCB at modest rate and make it adaptable to create circuits on any medium.

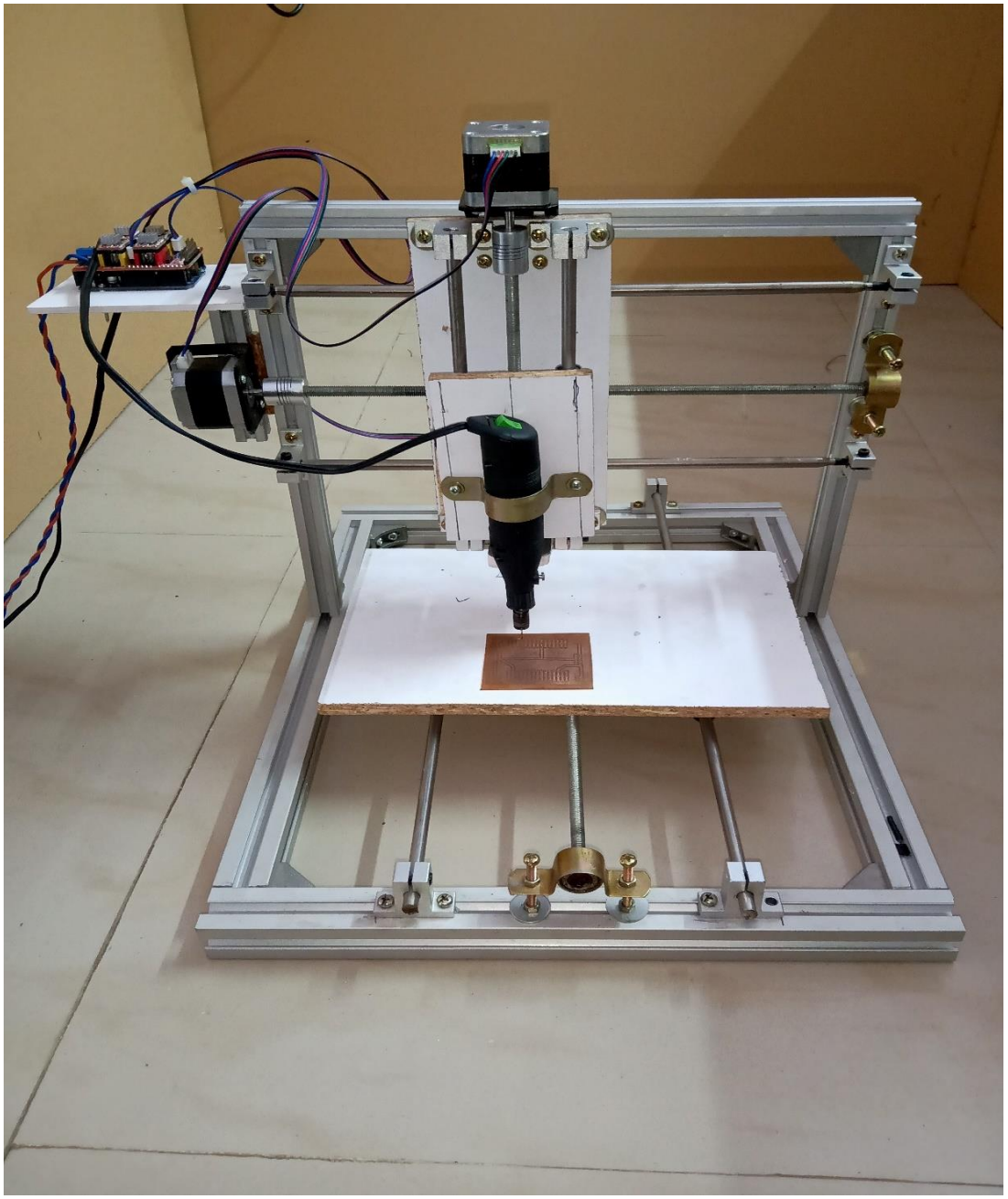
A low-cost automatic PCB drilling machine using basic electronics components. A performance for different dimension of boards and location of holes. The user can select the different distances between holes and can be used for same specified inputs for large scale production.

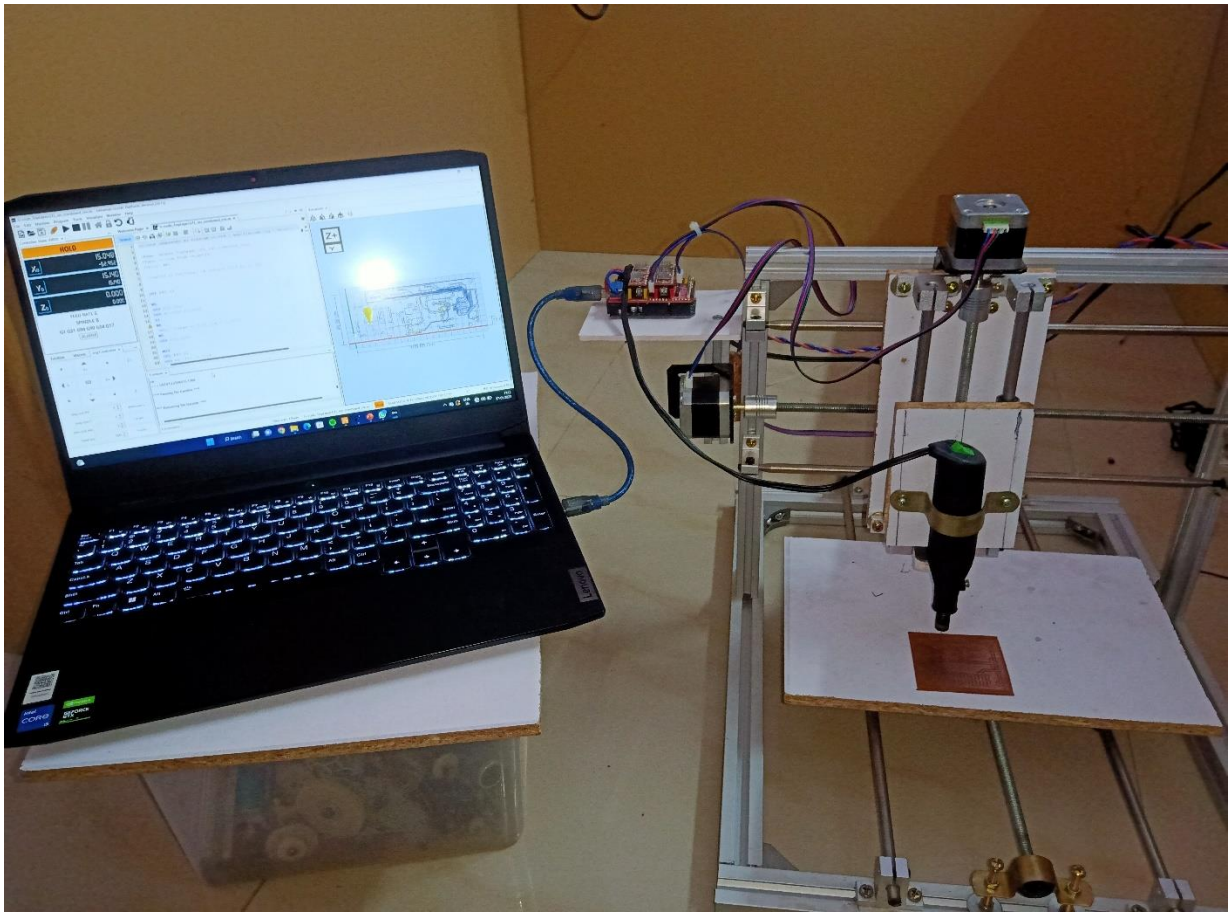
5.1FUTURE SCOPE

It is planned to scale up the prototype CNC machine in terms of size, use more powerful motors, strengthen the frame and worktable with materials like aluminum or cast iron, and augment the CNC control software with software for simulation ahead of actual run. For instructional purposes as well as for more precise operation, it is preferable to build CNC machines with DC or AC servomotors and encoder feedback using PC-based motion controllers

APPENDIX

[A] SNAPSHOTS





[B] DESIGN & G CODE FOR DRILLING

(G-CODE GENERATED BY FLATCAM v8.994 - www.flatcam.org - Version Date: 2020/11/7)

(Name: Drill_PTH_Through.DRL_cnc)
(Type: G-code from Geometry)
(Units: MM)

(Created on Saturday, 14 January 2023 at 15:29)

G01 F300.00

M5
G00 Z5.0000
T1
G00 X0.0000 Y0.0000
M6
(MSG, Change to Tool Dia = 0.8000 ||| Total drills for tool T1 = 46)
M0
G00 Z5.0000

G01 F300.00
M03
G00 X65.0000 Y25.1000
G01 Z-2.0000
G01 Z0
G00 Z2.0000
G00 X65.0000 Y23.1000
G01 Z-2.0000
G01 Z0
G00 Z2.0000
G00 X71.2000 Y20.0000
G01 Z-2.0000
G01 Z0
G00 Z2.0000
G00 X71.2000 Y29.0000
G01 Z-2.0000
G01 Z0
G00 Z2.0000
G00 X76.8200 Y31.9000
G01 Z-2.0000
G01 Z0
G00 Z2.0000
G00 X79.3600 Y31.9000
G01 Z-2.0000
G01 Z0
G00 Z2.0000
G00 X81.9000 Y31.9000
G01 Z-2.0000
G01 Z0
G00 Z2.0000
G00 X84.4400 Y31.9000
G01 Z-2.0000
G01 Z0
G00 Z2.0000
G00 X86.9800 Y31.9000

G01 Z-2.0000
G01 Z0
G00 Z2.0000
G00 X96.9000 Y43.8000
G01 Z-2.0000
G01 Z0
G00 Z2.0000
G00 X107.0000 Y47.0000
G01 Z-2.0000
G01 Z0
G00 Z2.0000
G00 X107.4000 Y11.3100
G01 Z-2.0000
G01 Z0
G00 Z2.0000
G00 X107.4000 Y8.7700
G01 Z-2.0000
G01 Z0
G00 Z2.0000
G00 X107.4000 Y6.2300
G01 Z-2.0000
G01 Z0
G00 Z2.0000
G00 X107.4000 Y3.6900
G01 Z-2.0000
G01 Z0
G00 Z2.0000
G00 X100.0000 Y3.0000
G01 Z-2.0000
G01 Z0
G00 Z2.0000
G00 X85.1000 Y4.0000
G01 Z-2.0000
G01 Z0
G00 Z2.0000
G00 X85.1000 Y11.6000
G01 Z-2.0000
G01 Z0
G00 Z2.0000
G00 X73.1000 Y6.1000
G01 Z-2.0000
G01 Z0
G00 Z2.0000
G00 X73.1000 Y4.1000
G01 Z-2.0000
G01 Z0
G00 Z2.0000
G00 X65.1000 Y16.6000
G01 Z-2.0000
G01 Z0
G00 Z2.0000
G00 X57.2000 Y16.6000
G01 Z-2.0000
G01 Z0
G00 Z2.0000
G00 X56.1000 Y13.0700

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