INTRODUCTION

A vision of tomorrows manufacturing products finding their way independently through the production process. In intelligent factories, machines and products communicating with each other co operatively driving the production . Raw material and machines are interconnected for the perfect manufacturing process, like drilling, milling, lathing etc. the objective of this CNC machine is to create the mass production. Previously in the first industrial revolution the manufacturing processes and drilling and all was taking place using the manual machine. So, revolutionary change in the world of digital electronics and microcontrollers the CNC machines are invented. Automatic PCB drilling can be achieved using this computer numerical control machine. Based on the numerical codes generated , the manufacturing processes can be controlled.

1.1 RELEVANCE

The Computer Numeric Control (CNC) is a technology which tries to bridge the gap between the computers and the mechanical system. It provides an easy and effective way to control the action of mechanical system by generating, parsing and executing the program instructions and converting them to the electrical signals to control the actuators which are used to control different actions of the machine. This paper reviews the sequence of works that have been carried out by different researchers on design, analysis, implementation and construction of a computer numerical controlled mechanical systems.

1.2 OBJECTIVES

The main purpose of doing this project is, this project will enable companies and engineeringstudents to make 2-D model of their project at ease. For a CNC machine an end millattached to the machine as spindle which cuts the material. The machine spindle can bereplaced with a laser engraver, plasma cutter, drill machine, water jet cutter drag knife or hotwire for a variety of applications making it more versatile.

1.3 ORGANIZATION OF PROJECT REPORT

Chapter 1: This chapter gives and introduction to the very first initial steps undertaken in order to proceed with the project. The chapter contain the section such as background study, relevance, etc. that refers to the main motivation behind this project.

Chapter 2: This chapter mentions the literature survey undertaken form various conference and journal papers that has been use as guidance and reference to accomplish the project.

Chapter 3: It consists of all detail schematics, circuit diagram, hardware specification used to build this project. Also the description of each major component along with the working.

Chapter 4: It consist detailed information about manufacturing..

Chapter 5: This chapter consists of the simulation result of the proposed system.

Chapter6: In this chapter consist of advantages and disadvantages of the proposed system.

Chapter 7: In this chapter the discussion and future work regarding the proposed system is discussed.

2.LITERATURE SURVEY:

- GautamJodh [1] discussed the design of **computer numeric control drilling machine**. Moving gantry type design of the machine was chosen. For frame structure **steel angles** were used to provide enough rigidity to the machine. Calculations were made considering different parameters to find out power requirements of the machine. For X, Y and Z axis drive, precision stepper motors were selected. The prebuilt open source software CMM was used to provide input to the machine. From the calculations and results, they concluded that machine had enough rigidity to work well even with mild steel.
- Venkata Krishna [2] has discussed the mechanical, electrical, and software subsystems of the **three-dimensional computerized numerical control machines**. Stepper motors, linear rails and gearing arrangement were used in the mechanical system, low cost 8-bit Atmel 89C51 microcontroller and ULN 2803 stepper motor driver comprised the electronics system, the C# .net platform 3.5 and Keil compiler were used as software subsystem. They concluded that the use of all the open source software and low-cost hardware optimized the cost of the machine.
- M. Bhavani [3] designed, implemented and constructed the **mini CNC machine for PCB drawing** and drilling, wood engraving and glass cutting. The GRBL firmware was used to interpret the G-code and converting it to electrical signals to control the actuators. The MCU used was Arduino Uno development board based on Atmega 328 microcontroller, which was responsible for controlling important parameters of the machine, like feed rate, depth of cut, and spindle speed etc. The GT2 timing belts were used instead of lead or ball screws to reduce the cost. The communication between the computer and the MCU was done using universal serial bus.
- Dr. B Jayachandriah [4] fabricated a **3-axis CNC router based on the three machine subsystems**. The mechanical system consisted of ball screws, ball bearings, linear rods, linear ball bearings, shaftsand shaft couplings. The electrical system comprised of power supply, stepper motors and microcontroller board. The free CAD software like FreeCAD were used to create the mechanical models to be fabricated on the machine. The CAM Software like G-Simple, Free mill etc. were used to generate G-code files to send to the machine controller using GCODE Sender software.

3.1 BLOCK DIAGRAM OF THE PROPOSED SYSTEM :

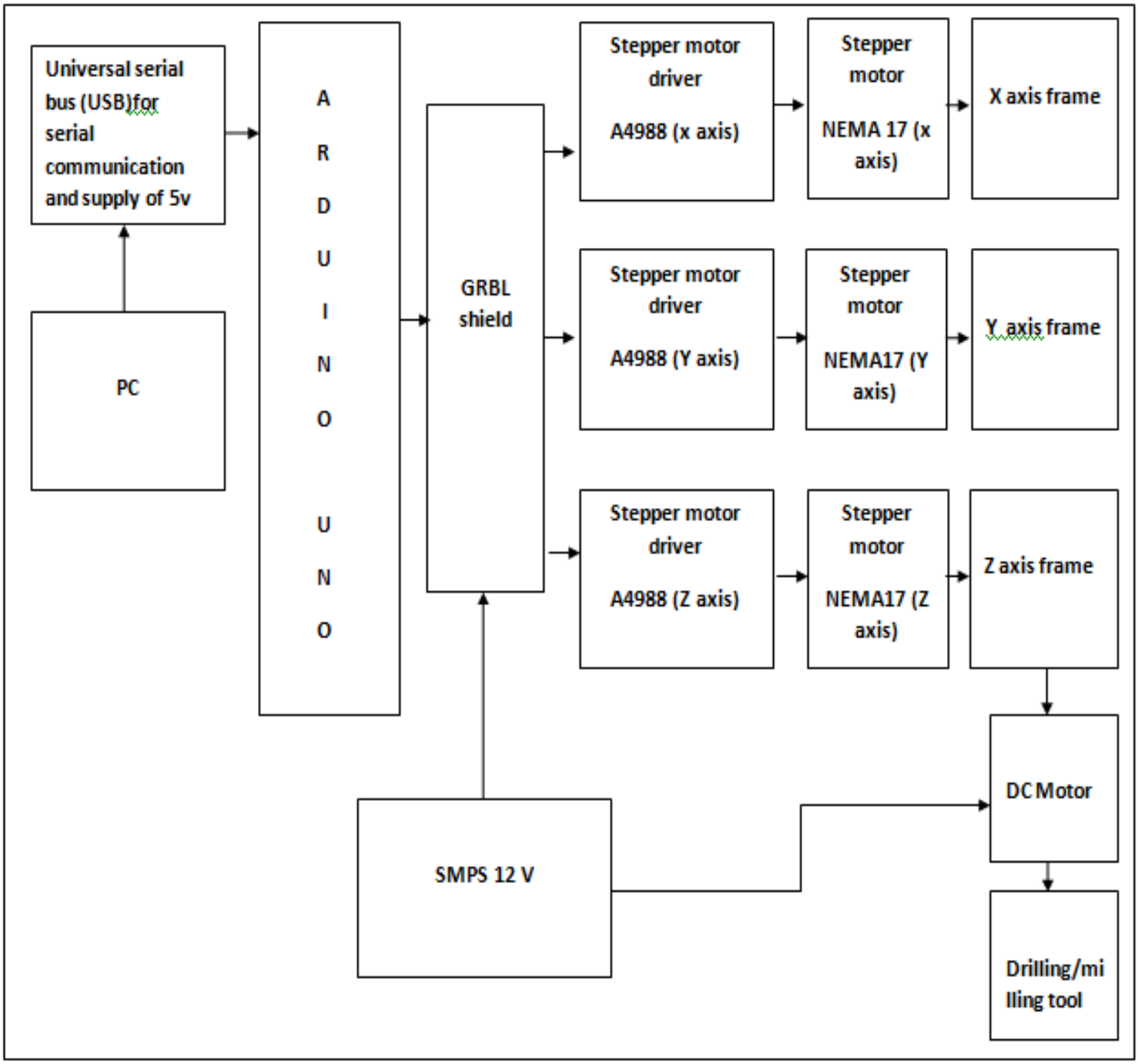


Fig.3.1. Block diagram of proposed system

Any system contains main three sections by which that system can work properly. This system also has that sections i.e. Input section, output section and control section.

3.2 DESCRIPTION:

INPUT SECTION

This section gives the G code generated from the eagle software and this .NC file and .GBR file is given to the FLATCAM software and these files are given to the GRBL software, this will generate the g code.

CONTROL SECTION

This is the main part of system responsible to whole control of the system. In control section we are going to control the stepper motors. Here the controlling element is ARDUINO and the GRBL shield which will control the stepper motors. And which in turn will control the drilling element.

OUTPUT SECTION

In output section we are going to see how microcontroller receives the data from the GRBL shield and how it controls the stepper motor. X-axis stepper motor is used for horizontal movement in right and left direction. Y-axis stepper motor is used for backward and forward movement. Z-axis stepper motor is used for vertical up-down movement. And as application is drilling application so the routing element is a drill machine.

3.3 CIRCUIT DIAGRAM OF PROPOSED SYSTEM:

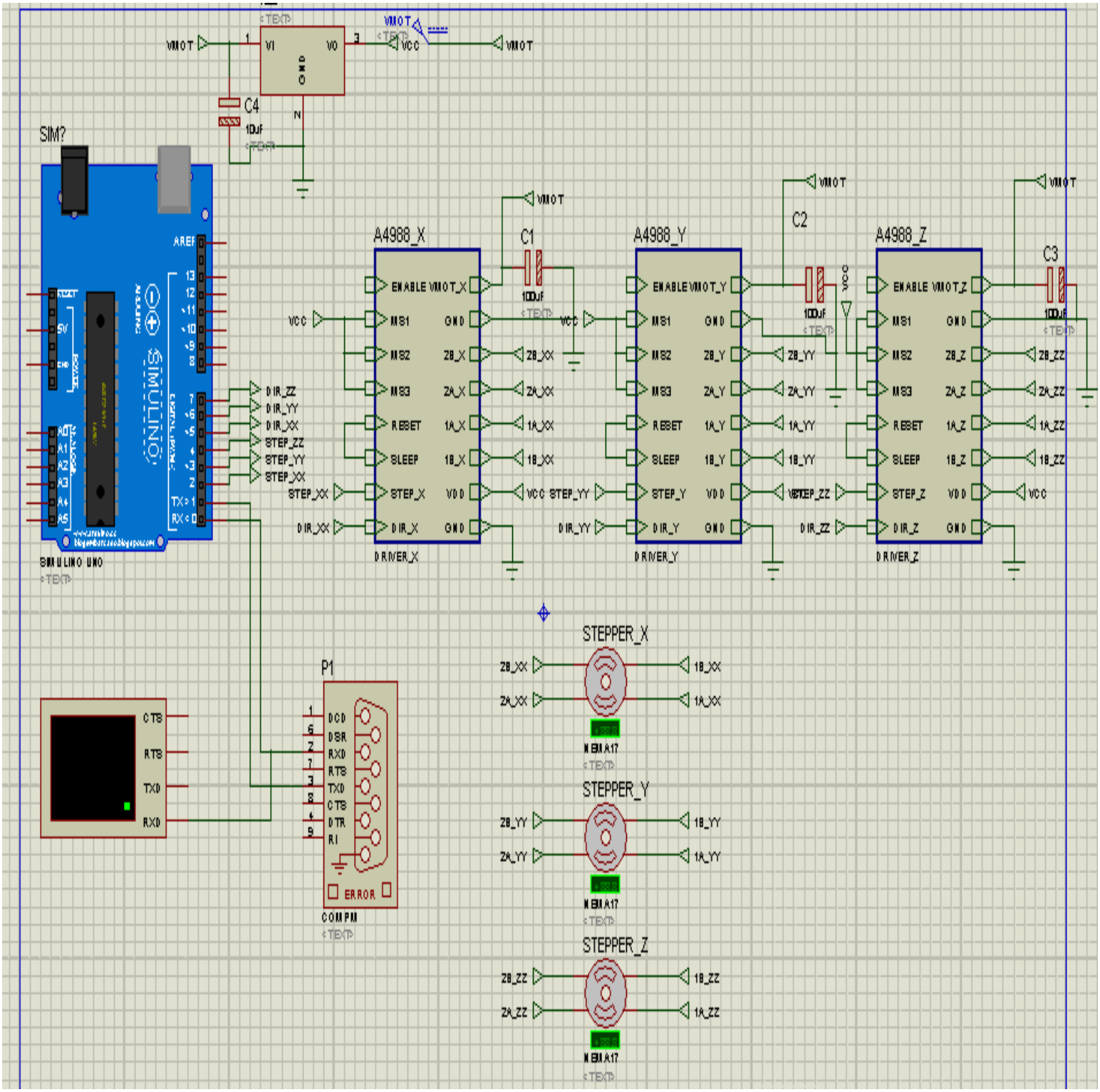


Fig.3.3 Circuit diagram of proposed system

PCBs drilling machine mainly consists of three blocks P.C (for software purpose), Controller Block and the Drilling machine. Computer which has software's like Eagle, FlatCAM , Universal G-Code sender forms the base for giving directions to the Controller Block. ARDUINO Microcontroller is very vital part in controlling the movements of axis on the drill machine. It also gives orders, when to start drilling and when to stop. There are three stepper motors connected in X, Y and Z axis movement. And they will be controlled or operated by the Atmega328 microcontroller connected to it. Of the three axis, two axis are used to move the PCB platform in x and y directions. And the one remaining that is z axis moves drilling machine in the vertical direction. As the PCB comes at the desired position, the third stepper motor moves the drilling machine along the third z (vertical) axis to drill there. This saves time and reduces errors due to manual handling and also gives much accuracy too. To make graphical sketch of the desired PCB and send all information to the microcontroller through FTDI . To make the .NC file and .GBR file by Using FlatCAM& Eagle software respectively.

As we complete the graphical presentation of the PCB layout, the software itself creates a file containing all the information about the PCB drilling, hole size, and hole positions on which we are going to make drill. All the data about the point where we have to drill is created in the FlatCAM software, this information involves two dimensional details of the point.

According to X-Y axis co-ordinate position the CNC Router will be moved and whenever it stops then starts the operation of Z axis . Z axis performs Up-down operation for drilling purpose.

4.1.HARDWARE DESCRIPTION:

1. ARDUINO UNO:

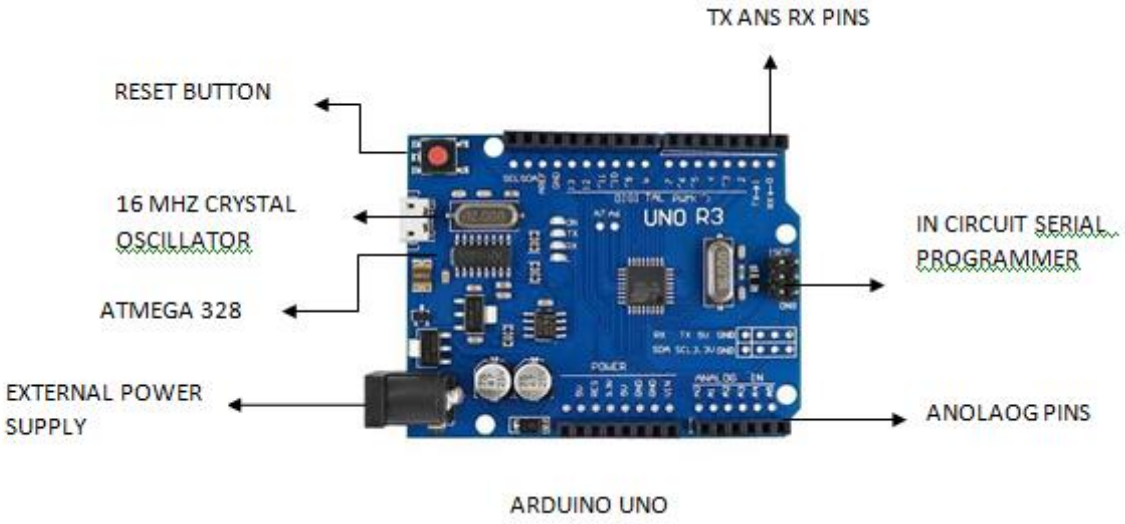


Fig.4.1 Arduino UNO

Arduino boards are mostly used in mega series of AVR microcontrollers developed by Atmel. These are 8 bit microcontrollers with on chip flash memory to program storage. Atmega8 , Atmega168, Atmega328 are primarily used microcontrollers. Arduino is the open source electronics platform based on easy to use hardware and software. It is a combination of microcontroller based Arduino boards, Arduino programming language and the Arduino software for the development and compilation. Arduino has evolved from being just an embedded environment to helping build advanced products for internet of things applications, wearable, 3D printing etc .Also being an open source platform hardware design schematics, PCB files and the codes for the software are freely available. This gives users flexibility to adapt and develop the design for their own projects. In this project,Arduino UNO is used as controlling unit in which the GRBL firmware is uploaded which is written in optimized C language. Arduino does the important job of G code interpreter.

2. STEPPER MOTOR NEMA 17:

We are using stepper motors of operating voltage of 8-20 V. The aim of stepper motors are to rotate or move the plate of PCB in X and Y direction using a G code. The Stepper motors are interfaced with controller by using stepper motor driver.These motors are used for the precise position control. These motors behave exactly the same as the brushless motor only the step size being much smaller in this case. The only moving part is the rotor which contains the magnet. The magnet structure of the stepper is what allows the stepper motor move in small steps as the polarity of the windings is varied.The step angle of the stepper motor is the angle through which the motor rotates in a single step. The NEMA17 stepper motor that we will be using as a part of this project has a step angle of 1.8 degrees. From this we also conclude that 200 pulses are required for full revolution of 360 degrees of the motor shaft.

Fig.4.2 Stepper motor NEMA 17

Specifications:

- Holding Torque : 5 Kg.cm
- Step Angle : 1.8 Degree
- Current A - 1.68, Resistance (ohms) - 1.65, Inductance (mH) - 2.8
- Dimension : 42mm x 42mm x 47mm (H)
- No. Of leads - 4 (bipolar) comes with 1 Meter Cable and Dupont Connector
- Weight: 300.0 gm

3. STEPPER MOTOR DRIVER (A4988):

Stepper motor driver are used to drive the stepper motor by giving the specified operating voltage. We are using Stepper motor driver A4988 for driving the stepper motor.A stepper motor driver is used to drive the stepper motor by providing it appropriate operating voltage. It is nothing but acts as a voltage level booster. It is mounted on the GRBL shield. It gets the input from the microcontroller and it drives the stepper motors accordingly.

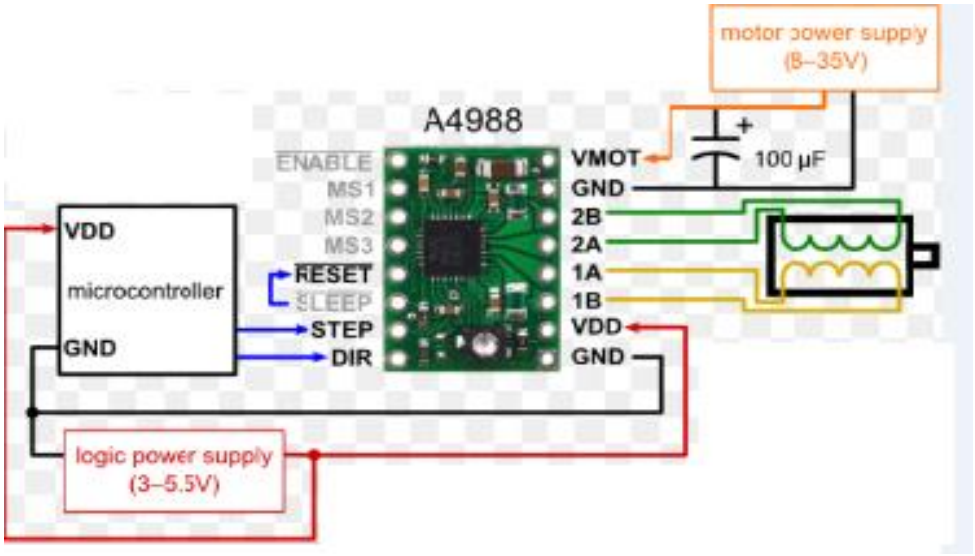


Fig.4.3 Stepper motor driver A4988

- The A4988 is a complete micro stepping motor driver with built-in converter, easy to operate
- The products can be in full, half, 1/4, 1/8 and 1/16 step mode of operation bipolar stepper motor, output drive performance up to 35 V and ±2 A
- A4988 includes a fixed off-time current regulator, the regulator can be in slow or mixed decay mode

4. Universal Serial Bus:

USB Is used to interface the microcontroller to the personal computer. It also used for the purpose of serial communication. When the Arduino is connected to the PC a particular com port gets assigned to it. After that we can say Arduino is ready for the execution process.

Fig.4.4.USB

5. 1000 RPM GEARED DC MOTOR:

A 1000 RPM 12V DC Geared motor is high quality low cost DC Geared motor. It has steel gears and pinions to ensure longer life and better wear and tear properties.

Fig.4.5.1. DC geared motor

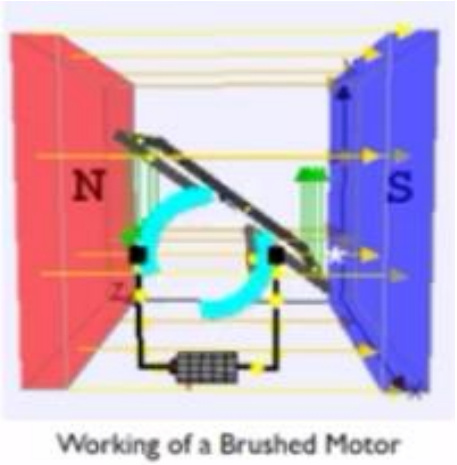


Fig.4.5.2.working of DC motor

It helps to run the spindle of the machine which in turns rotates the cutting tool. The spindle consists of a DC motor the main function of it is to cut metal with high speed and accuracy.Universal Serial Bus:

USB Is used to interface the microcontroller to the personal computer. It also used for the purpose of serial communication. When the Arduino is connected to the PC a particular com port gets assigned to it. After that we can say Arduino is ready for the execution process.

6. GRBL SHIELD :

GRBL is ready for light duty production. We use it for all the milling, running it from our laptops using great user-written GUIs or with a simple console script to stream the g code.

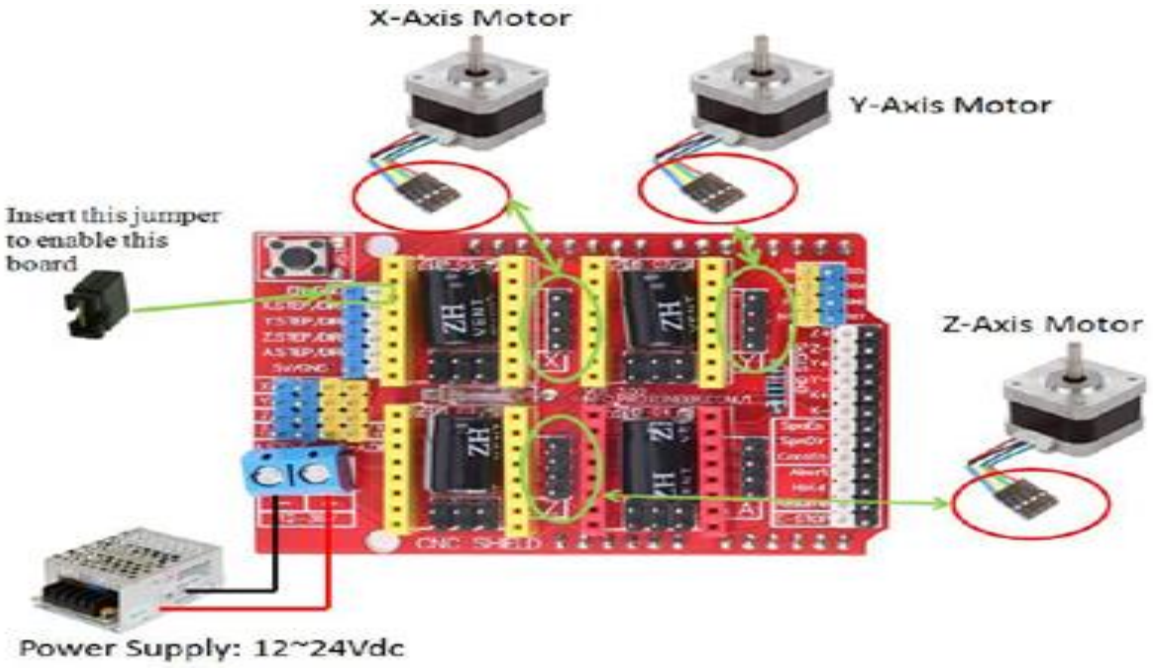


Fig.4.6 GRBL shield

It is written in optimized C utilizing all the clever features of the Arduino's ATmeaga328p chips to achieve precise timing and asynchronous operation. It is able to maintain more than 30khz step rate and delivers a clean and jitter free stream of control pulses.GRBL is for three axis machines.The GRBL software runs the machine very smoothly with excellent acceleration and

deceleration control. GRBL looks for lines of G code passed over the USB and also manages all of the timing necessary which allows for the machine controller to the computer agnostic.

"It is an open source, high performance G code parser and CNC milling controller written in optimized c language that will run on straight Arduino."

Features of the GRBL:

- It enables communication over USB .
- GRBL has many advanced parameters,.

7. SWITCH :

A switch is used for toggling purpose. When the switch turned on the DC motor will start rotating and as soon as the switch is turned off the motor will get turned off.

Specifications:

- Current Rating : 6A
- Frequency : 50Hz
- Voltage : 220-240 V
- Material: Poly-Carbonate

Fig.4.7 Electric Switch

8. SMPS:

For the purpose of providing the power supply to the entire system we are using the SMPS i.e. switched mode power supply. We are providing this supply to the GRBL shield and to the DC 1000 RPM motor.

Specifications:

- Model: ME360W
- AC input: 110/220 +- 15%
- DC output : 12 V , 30A

Fig.4.8 SMPS 12 V, 30A

4.2 SOFTWARES REQUIRED :

1. EAGLE SOFTWARE :

Drawing a circuit through this software will generate the .GBR file and one file without any extension.

2. FLATCAM SOFTWARE:

This software is used to generate an **.NC** file.

3. UNIVERSAL G CODE SENDER SOFTWARE : This is used to send the G-code files(**.NC**) to an integrated hardware interpreter(Atmega 328).This software will take a G-code program in file and send it line-by-line to the Atmega 328 microcontroller. The Gcodes will send over the serial ports through USB communication between the computer and microcontroller**.** Universal G-Code Sender Software.is software that is designed to send GCode to CNC machines.According to X-Y axis co-ordinate position the CNC Router will be moved and whenever it stops then starts the operation of Z axis.Z axis performs Up-down operation for drilling purpose.

4. CNC SIMULATOR :

To check how our CNC machine will work in future we can ckeck it using this software. In this software we have to chose the prototype of the CNC machine that we want and then after giving the G code commands we can see the simulation i.e. CNC machine working.

4.3 MECHANICAL HARDWARE REQUIRED:

- PLYWOOD AND MDF MATERIAL
- TOOLS AND CHUCK
- ALUMINIUM STEEL BAR
- THREADED STAINELSS 8mm ROD
- M8 NUTS
- DRILL MACHIENE
- MOTOR CLAMPS
- COUPLER
- LINEAR RAILS

Fig.4.3 Mechanical tools / components

4.3.1. Leadscrews:

Leadscrews translate turning motion into linear motion; we will be coupling these to stepper motors to control the translation of the machine tool along the three axes. When selecting a lead screw we need to consider the pitch of the lead screw which ultimately decides the basic length unit of the CNC machine. Lead screws convert the rotating motion of the stepper motor into the linear motion.

The basic length unit is the minimum distance that a machine tool will move and can be found by dividing the pitch by the number of pulses per revolution.

In this project we have used the stainless steel threaded lead screw of lengths 420mm, 250mm, and 70mm.

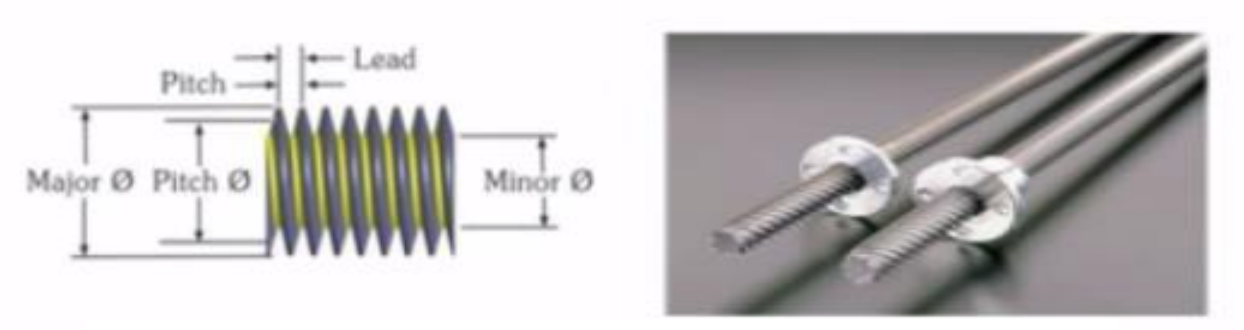


Fig.4.3.1 Leadscrews

4.3.2. Linear bearings:

Fig.4.3.2 Linear Bearings

Description:

-Type: Ball bearing

- Great for linear motion on 3D Printer, CNC, and other applications

- Inside diameter: 8MM

- Outside diameter: 14MM

Specification:

- Length: 23mm

- Material: Stainless Steel

4.3.3 Smooth steel rods:

In thus project we have used the steel rods of lengths 430 mm and 300 mm for making frames/ axes easy to move according to the user drilling requirements.

Fig.4.3.3 steel rods

Specifications:

- Outside Diameter: 8mm
- Length: 300 mm , 430 mm
- Material: EN-31 (Hard Chromed)

4.3.4 Coupling set:

In thus project we have used the three number of couplers to hold or fix the or couple the lead screw with the stepper motor for the movements of the x, y and z axes . The size of the couplers is about (5 to 8mm).

Specifications:

- Size: 5 mmx8mmxx25 mm
- Only for CNC
- Length:25 mm
- Outer Diameter:19mm
- Shaft coupler Often used to connect servo motor, stepper motor,encoder, screw driving, machine platform.

Fig.4.3.4 shaft coupler

4.3.5 Tool holder chuck:

As the name suggest the tool holder chuck is to hold the drilling tool which we will be using to drill the particular job or to drill the copper clad.

Fig.4.3.5 Tool holder or collet chuck

Specifications:

- Length: About 72mm, DIY Supplies: Metalworking, Type: Center Drill Bit, Use: Metal Drilling, Material: High Speed Steel.
- Type: Drill Chuck, Usage: Wood Plastic Stone Drilling, Feature 1: Collet Chuck, Feature 2: Dremel Chuck, Feature 3: Mini Drill Chuck, Feature 4: Dremel Accessories, Feature 5: Power Tool Accessories
- 1X Generic 1pc 0.3-6.5mm Black Keyless Drill Chuck Screwdriver Impact Driver Adaptor Chuck Collect 6.35mm Hex Shank Drill Bits Power Tool.

4.3.6 Allen key:

In this project we are using the Allen key to tighten the stepper motor with that of the lead screw. Allen bolt of 3*15mm and Allen key of 2.5mm is used for this purpose. The Allen key is used to tighten the screws or couple the stepper motor with the lead screw and the Allen bolt is used to fix the stepper motor with the x, y and z axes.

Fig.4.3.6 Allen keys

4.3.7 Drill bit:

We are making this project for the fulfillment of the drilling operation which is done automatically. the drill size can be varied by varying the size of the drill bit used. We have two motives in this project we are going to drill not only a PCB but also any wooden block.

We are using 4mm and 0.5mm drill bits for these operations.

Fig.4.3.7 Drill bits

Specifications:

- Uses for wood, plastic and metal
- Helix flute design will make the drilling be more easy and effortless Features: Straight shank straight shank design is more suitable for many electric drills Bit Size Approximate (Diameter x Length): 1.5 x 4mm, 2 x 49mm, 2.5 x 56.7mm, 3 x 60mm, 3.2 x 63mm, 3.5 x 70mm, 4 x 74mm, 4.5 x 80mm, 4.8 x 80mm, 5 x 86mm, 5.5. x 91.7mm, 6 x 93.6mm, 6.5 x 98.5mm
- Gross Weight: 120g
- Product Specifications, Package Contents: 13 x drill bit

4.3.8 Motor clamps:

The motor clamps play the vital role in this project. They make the machine more rigid. Because of these motor clamps we can move the machine from one place to another. The purpose of using these motor clamps is this that with the help of them we are going to fix the lead screws with that of the frames. So that when the motor will be on the lead screw will rotate and along with that our three axes will rotate. With the help of nuts and windings we have fixed the lead screw with that of the axes. U clamps and vertical and horizontal L clamps are used.

Fig.4.3.8(a)u clamps

Fig.4.3.8(b) L clamps

4.3.9 MDF material:

The MDF i.e. medium density fireboard is used for the purpose of making the structure of the machine as well as the main aim is to reduce the cost of the machine we are using MDF material for our machine which is stronger than wood and cheaper than aluminium.

Fig.4.3.9 MDF board

4.4 CNC INTRODUTION :

4.4.1 MACHINING :

Shaping a workpiece by removing material from it is termed as machining. There are various types of machines such as drilling machine, Lathe machine, Milling machine etc.

4.4.2 NUMERICAL CONTROL :

Numerical control is nothing but it's a programmable automation. Here, the processes are controlled by numbers,letters,or symbols.

The basic components of the numerical control are as:

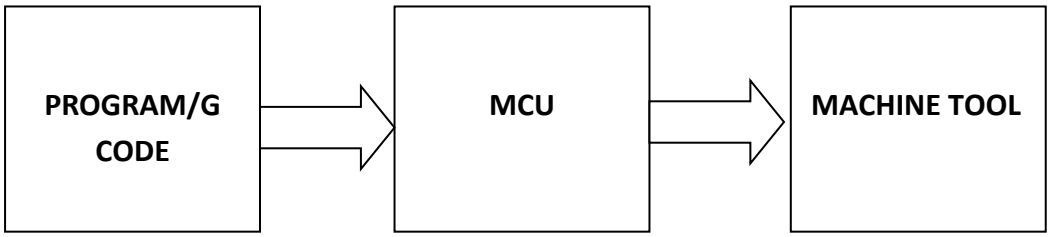


Fig.4.4.2. Basic components of numerical control

4.4.3 CNC MACHINE :

Microprocessor based system which store and processes the data is called as a CNC machine.

CNC system is the brain of CNC machine.

4.5. ELEMENTS OF CNC

The elements of CNC are as :

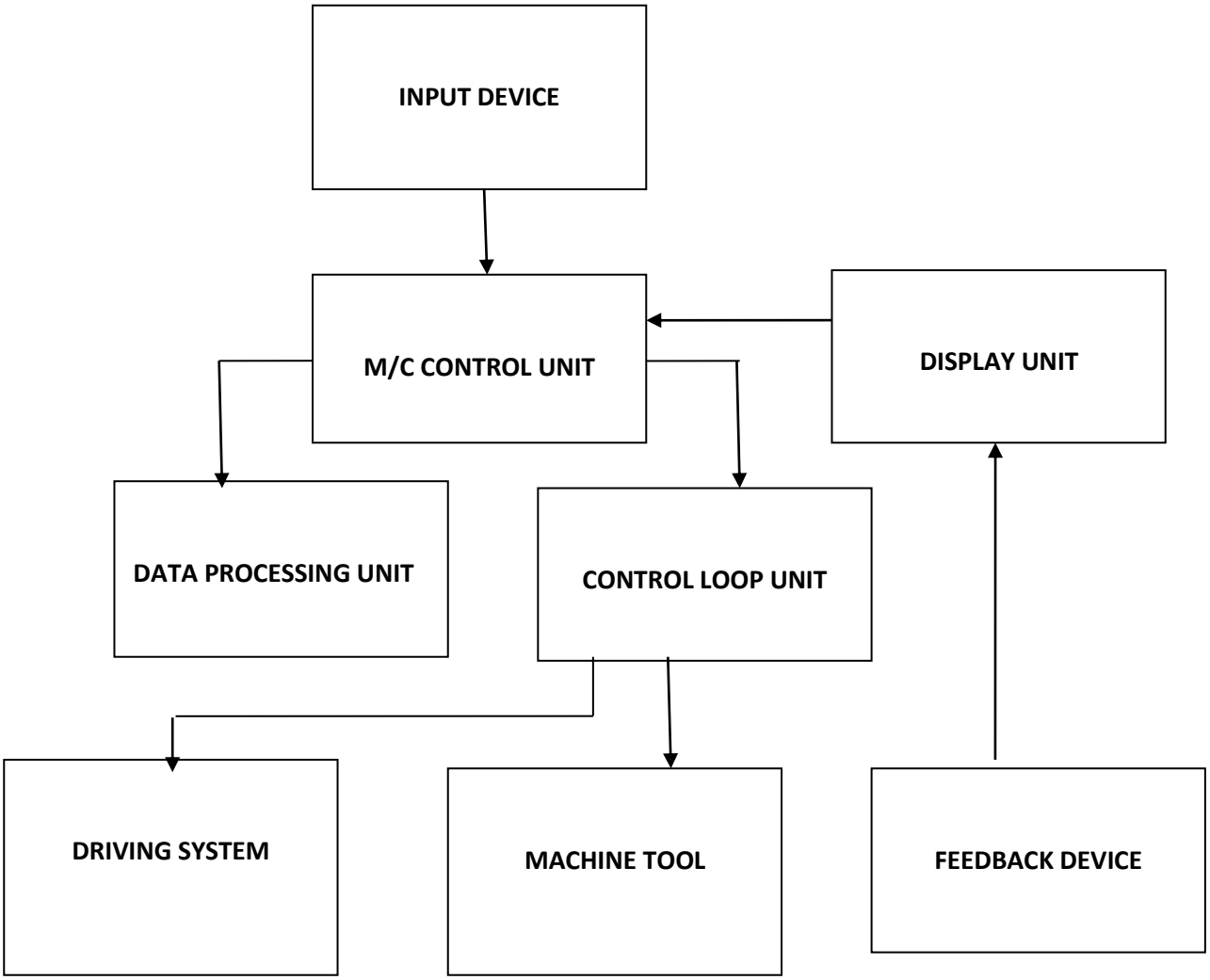


Fig.4.5 Elements of CNC

4.5.1 INPUT DEVICES –

It provides the data of the machine to be designed. USB ,serial communication, Ethernet, Conversational Programming etc are used as input devices .

4.5.2. MACHINE CONTROL UNIIT :

It is called as the heart of the cnc machine. It controls the machine tool movement according to the input data given. Input data about the part is encoded and sent by this unit. It consists of the two units such as : 1. Data Processing Unit , 2. Control Loop Unit

1. DATA PROCESSING UNIT :

ARDUINO UNO acts as the DPU. It interprets the part program into internal machine codes. Here the interpolator Is used to calculate immediate position in terms of basic length unit (BLU).

2. CONTROL LOOP UNIT :

It is 3 Axis motor unit control. It converts the DPU data into electrical signals. To perform driving system required operation. E.g. machine on/off, spindle on/off etc.

4.5.3 DRIVING SYSTEM :

It helps in driving the machine slide or spindle. It generally uses the stepper motor or DC motor. It also uses the leadscrews / belt drivers to translate rotational motion into linear motion.

Motor is coupled through gear box to leadscrews to move machine slide / spindle.

4.5.4 MACHINE TOOL :

It can be any type of machine tool/equipment.

Characteristics:

- Rigid machine structure
- Accurately machine slides
- Quick change tooling system.

4.5.5 FEEDBACK DEVICES :

Feedback about the proper functioning of the machine tool is sent to the MCU using sensors.

Feedback is used to accurately operate the machine tool. Control loop unit sends the operation control commands to the feedback system. Feedback system consists of the position sensor which gives information about the position of the tool and tachometer which measures the RPM of the motor operating the tool and generates output in terms of voltage.

In this ways the speed and the position of the tool is constantly updated.

4.5.6 DISPLAY UNIT :

Displays the CNC machine status such as :

- Position of the machine slide
- Spindle RPM
- Feed rate
- Part program
- Graphic simulation of the tool path.

4.6 STRUCTURE OF CNC

4.6.1 AXIS IN CNC MACHINE :

There are three axes in CNC machine e.g. X axis, Y axis and z axis.

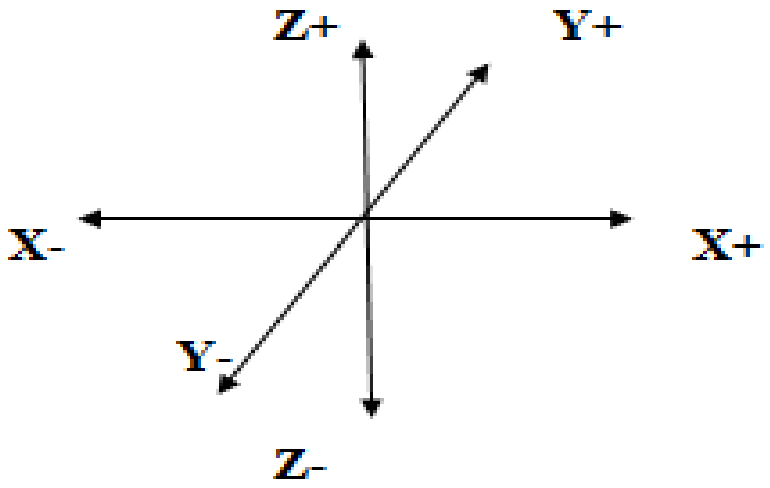


Fig.4.6.1 Axis in CNC machine

4.6.2 BED TYPE –

There are two types of beds : 1. Mobile bed and 2. Stationary bed .

1.MOBILE BED -

- It is found on smaller CNC machines.
- Rigid structure
- Limit on overall size.

2. STATIONARY BED -

- Size is limitless
- Versatile design
- Gantry flexes under greater load

4.6.3 CUTTING AREA :

It is nothing but the total distance the machine can cut along each axis. It decides the machine size.its expensive to hold tight tolerances in greater machines.

4.6.4 MATERIAL AND TOOLS :

Material used for manufacturing the CNC is as :

- Plastic
- Wood
- Medium density fireboard
- Aluminum

out of these material MFD is used , as It is stronger than wood and cheaper than aluminum

4.6.5 STRUCTURAL ELEMENTS :

Main structural elements are as –

- Base : it acts as a frame and it holds everything together.
- Axis frames : it does the movements of tool in different axes.
- Guides : move axes linearly.

4.6.6 TYPES OF FRAMES :

1. FULLY SUPPORTED FRAMES

In this type of the frame both Y and X axis may rest on the floor. So, it allows CNC assembly rigid and sturdy.

2.PARTIALLY SUPPORTED FRAMES

In this type one axis rests on the floor and other supported on ends. The chances of deformation and vibration on the axis which is supported on the ends is high.

4.6.7 LINEAR MOTION ALONG 3 AXES :

1. LINEAR MOVEMENT SYSTEM :

It consists of the Leadscrews and guides.

2. DRIVING SYSTEM :

it consists of the stepper motors and DC motors.

4.7 DESIGNSTRUCTURE OF THE CNC MACHINE :

The structure we are using for building our CNC machine is fully supported , stationary bed type and material to be used will be MFD as it is cheaper than aluminum and stronger than wood.

4.7.1 BASE FRAME :

It consists of the two side frames , idler frame and motor frame.

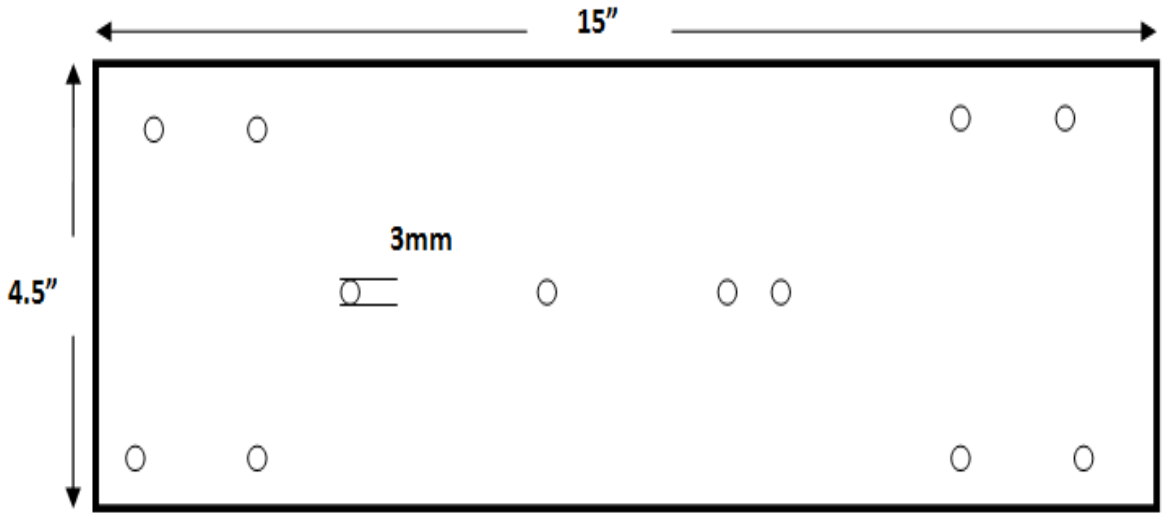


Fig.4.7.1.a.side frame 1

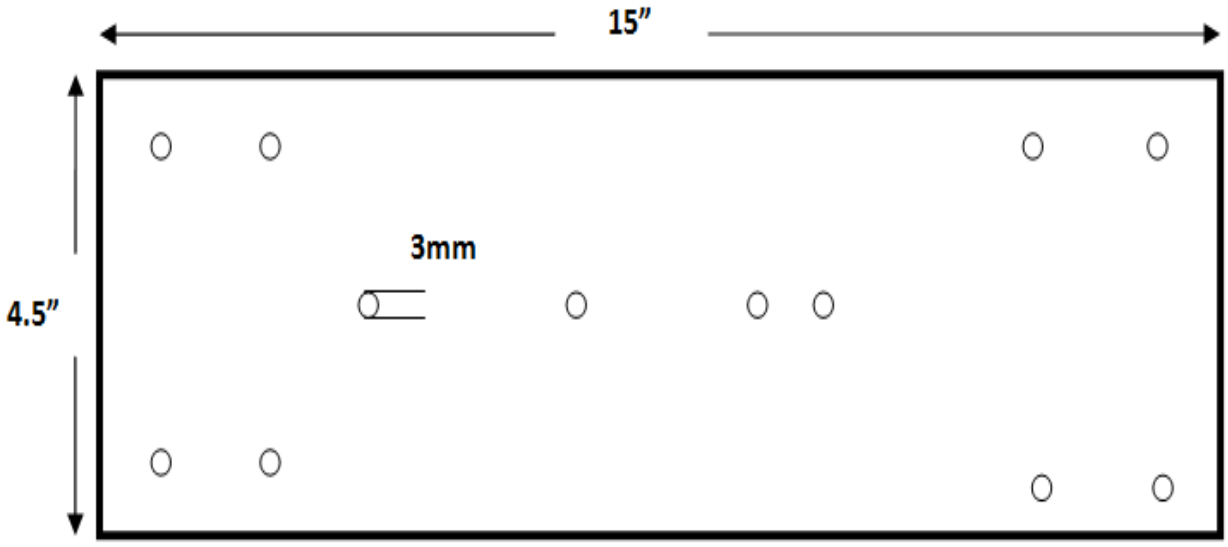


Fig.4.7.1. b. Side frame 2

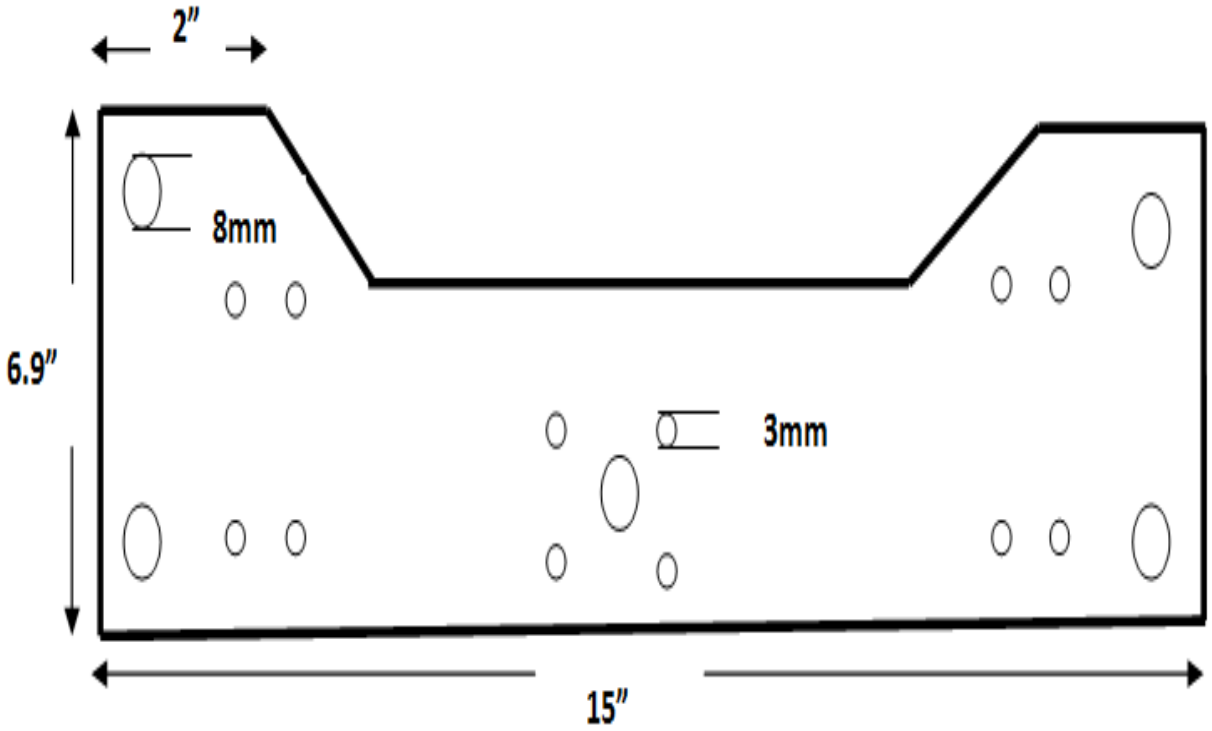


Fig.4.7.1.c. Idler frame

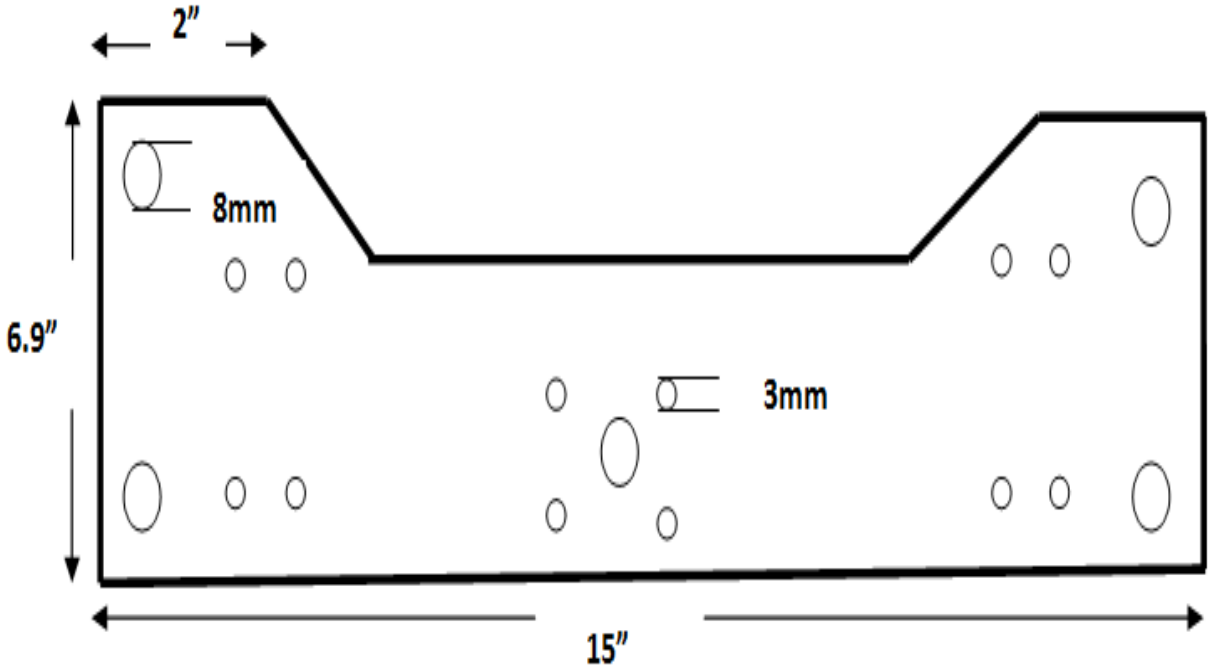


Fig. 4.7.1.d.motor frame

4.7.2 Y AXIS FRAME –

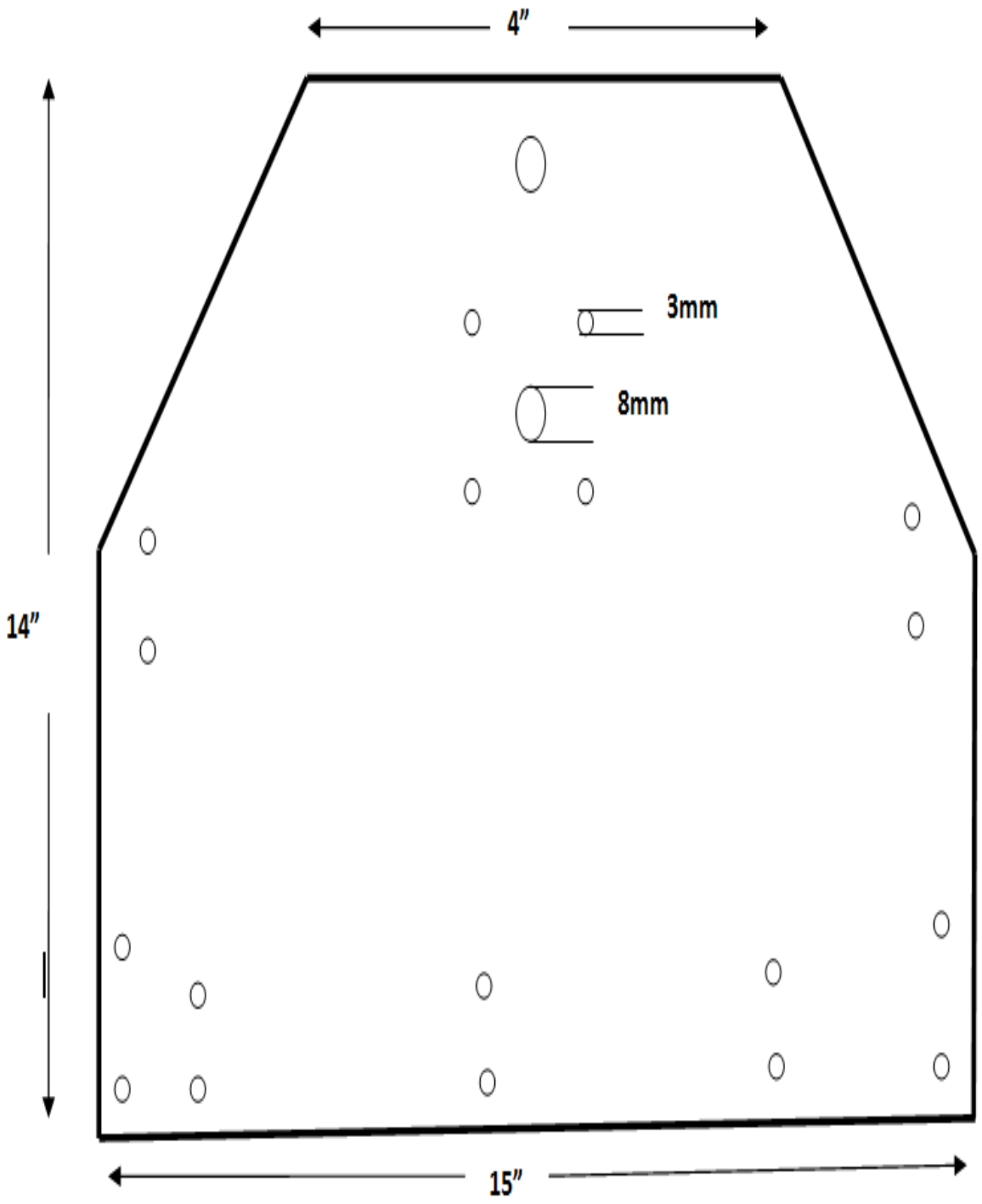


Fig.4.7.2(a) y axis motor frame

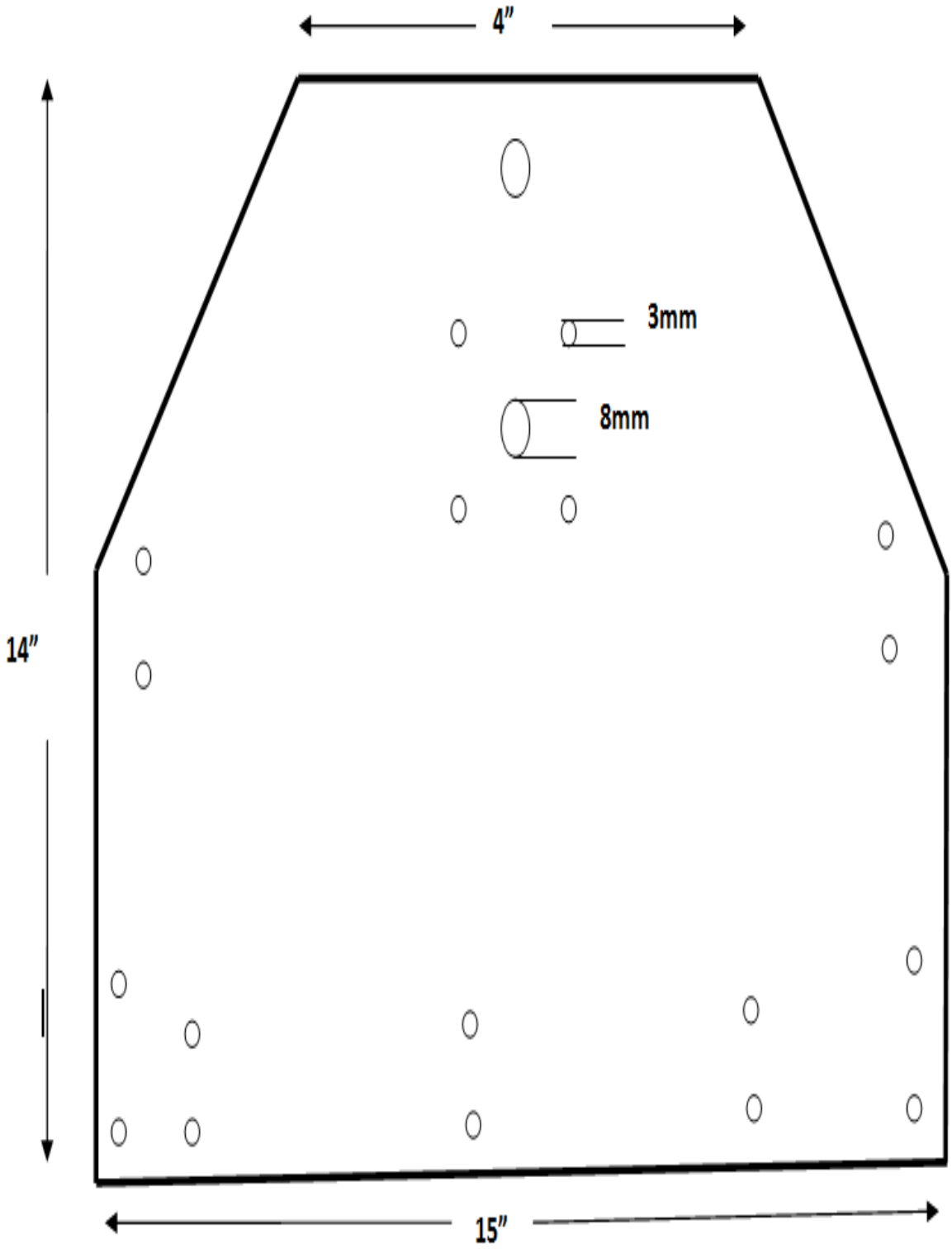


Fig. 4.7.2(b)y axis idler frame

4.7.3 X AXIS FRAME DESIGN –

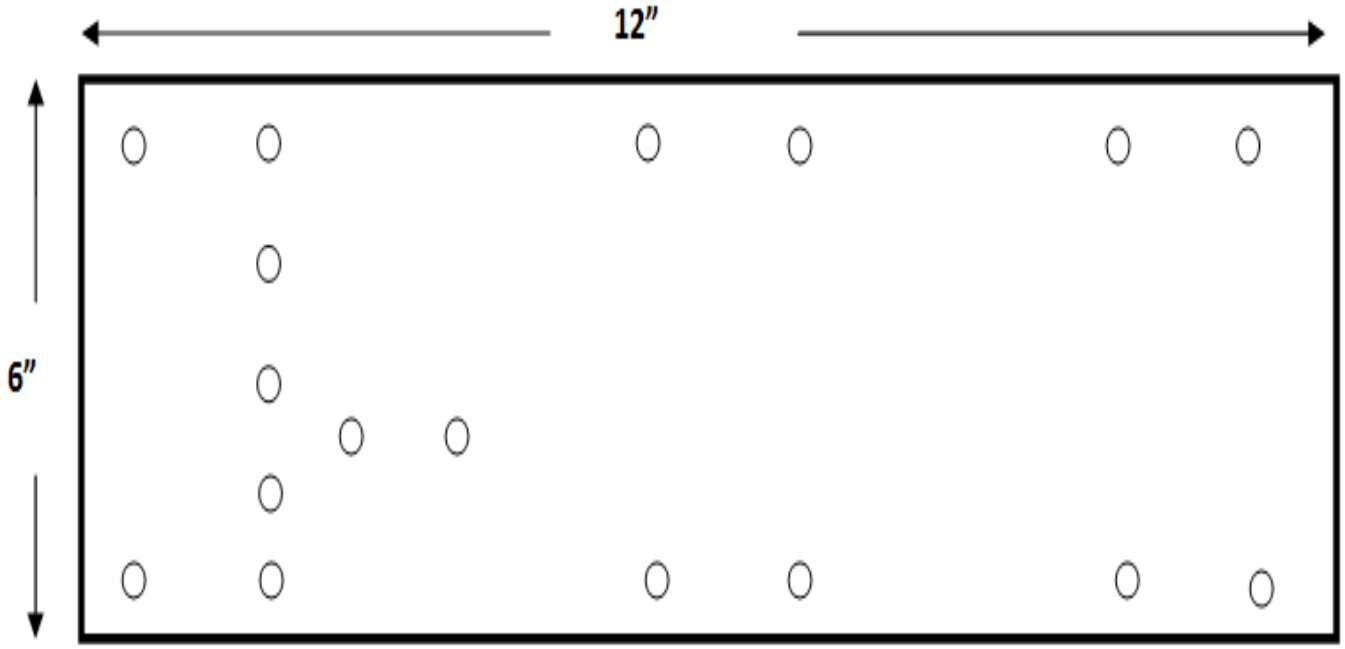


Fig.4.7.3(a) x axis idler frame

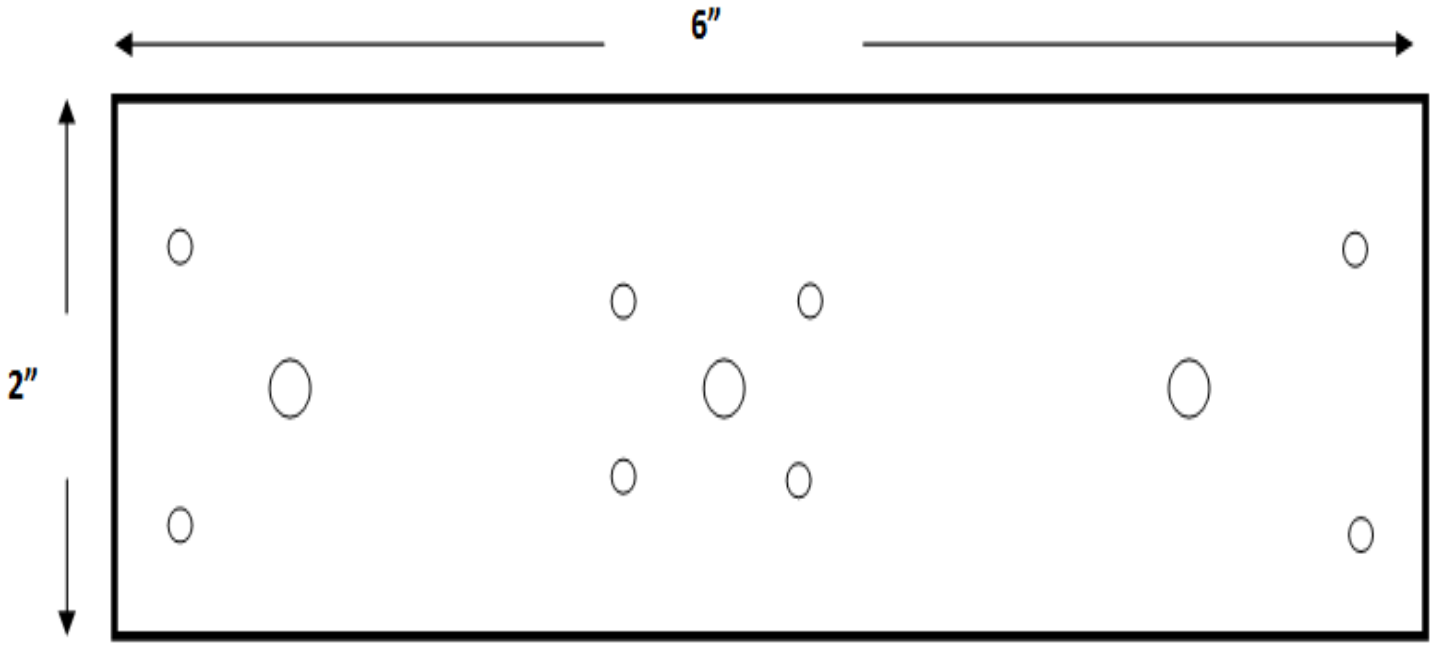


Fig. 4.7.3(b) x axis motor frame

4.7.4 Z AXIS FRAME DESIGN –

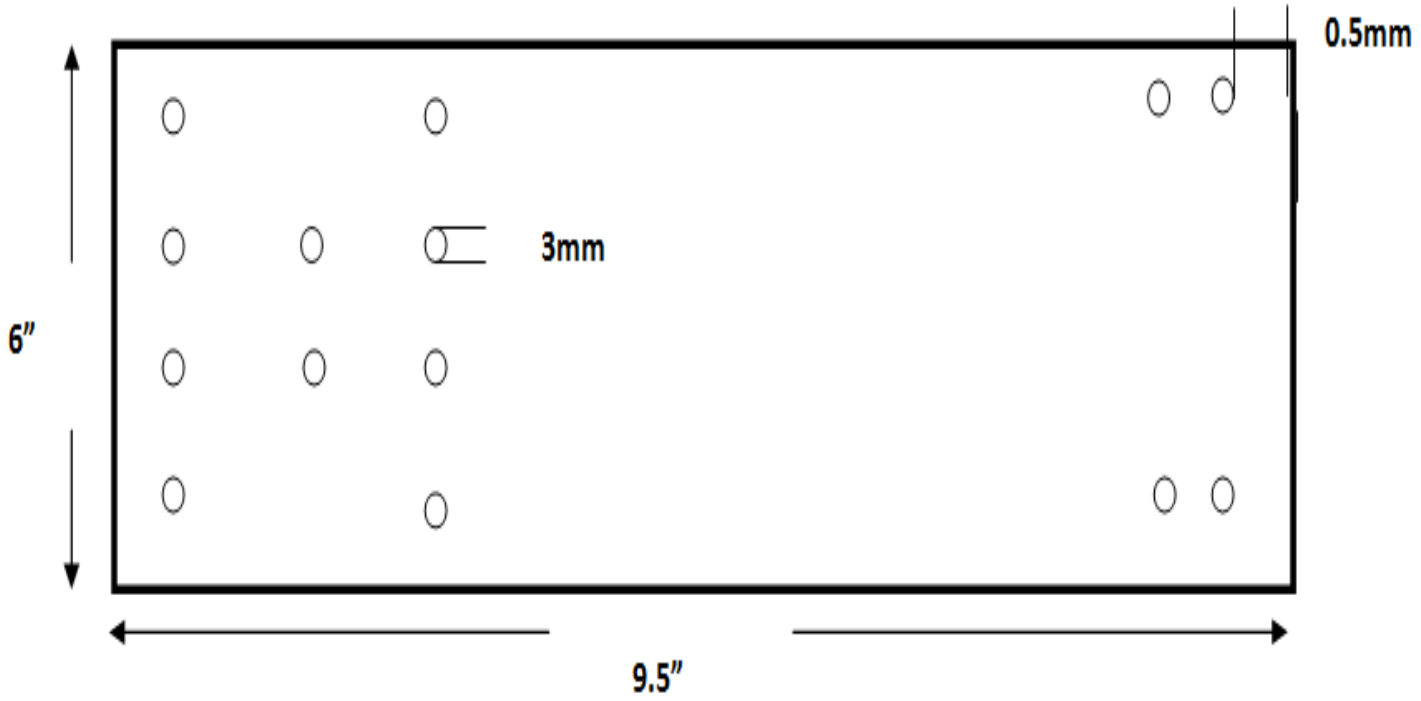


Fig 4.7.4(a) z axis frame

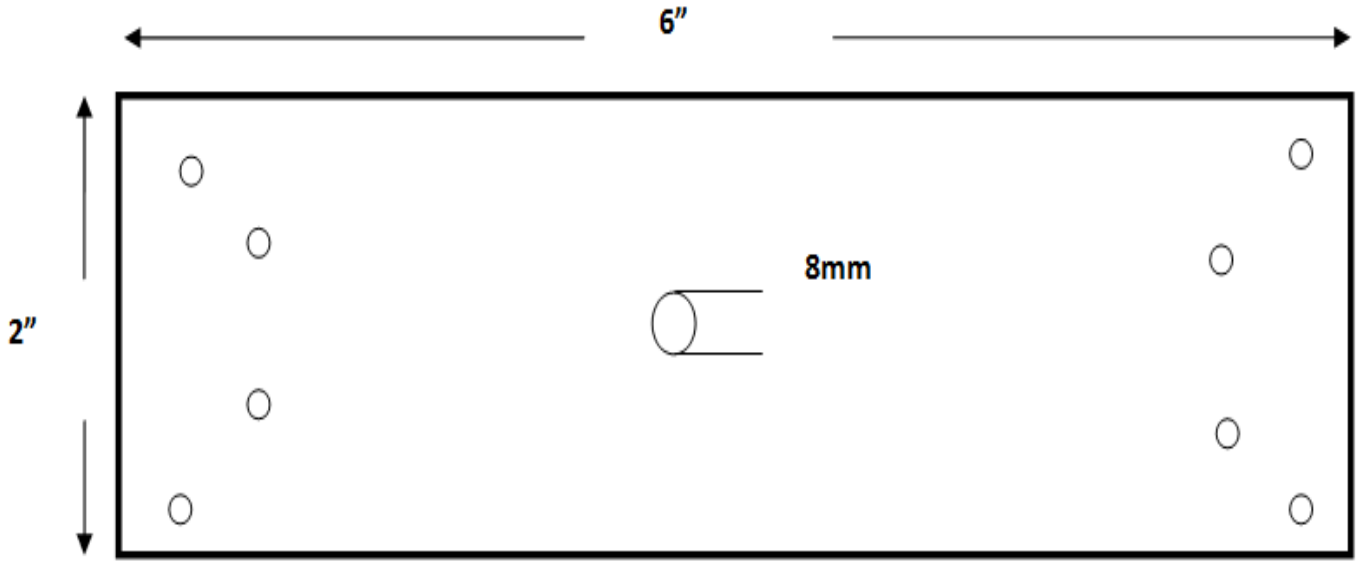


Fig 4.7.4(b) z axis side frame

4.7.5. BED ASSEMBLY :

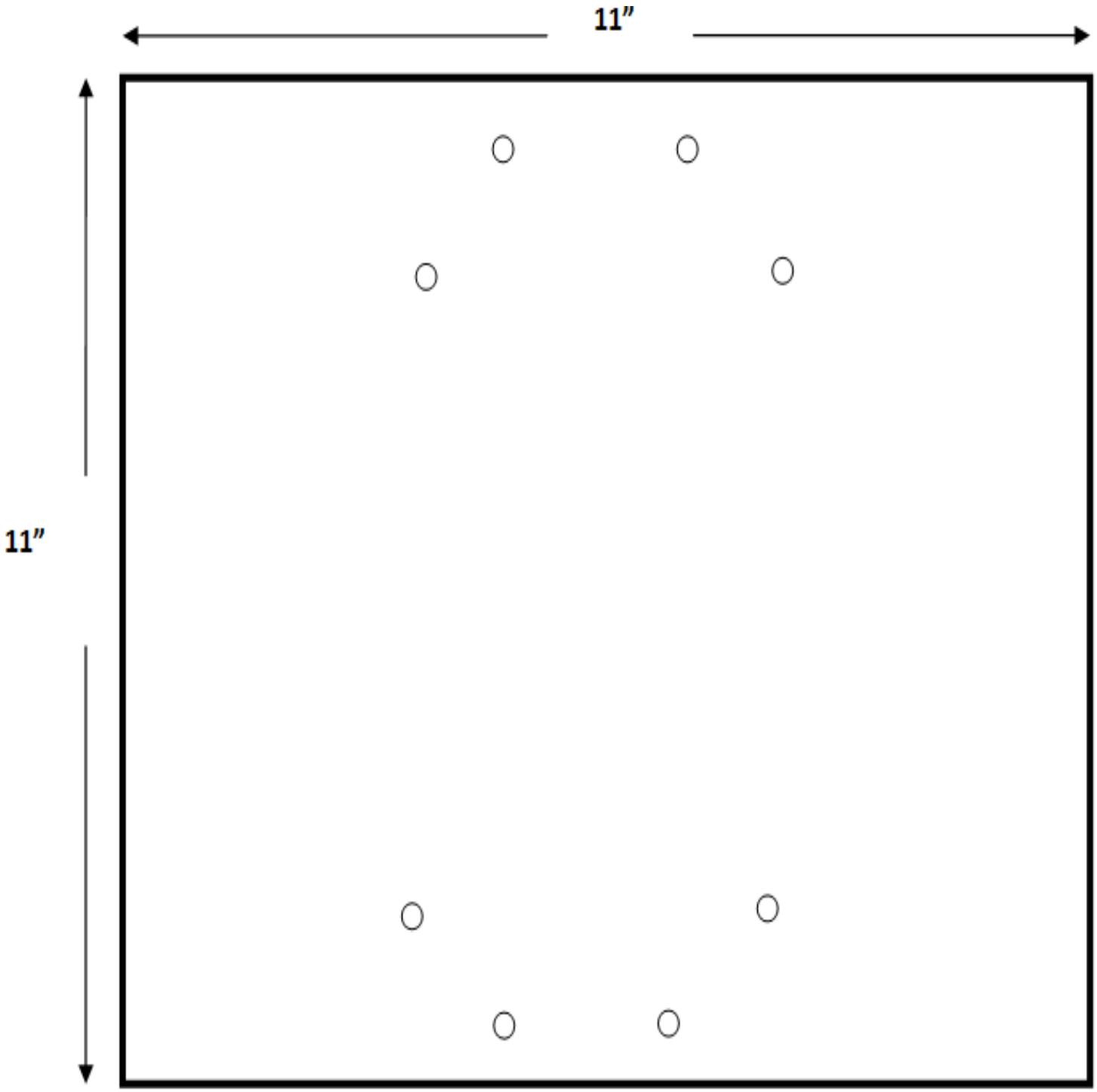


Fig.4.7.5.(a) base plate 1

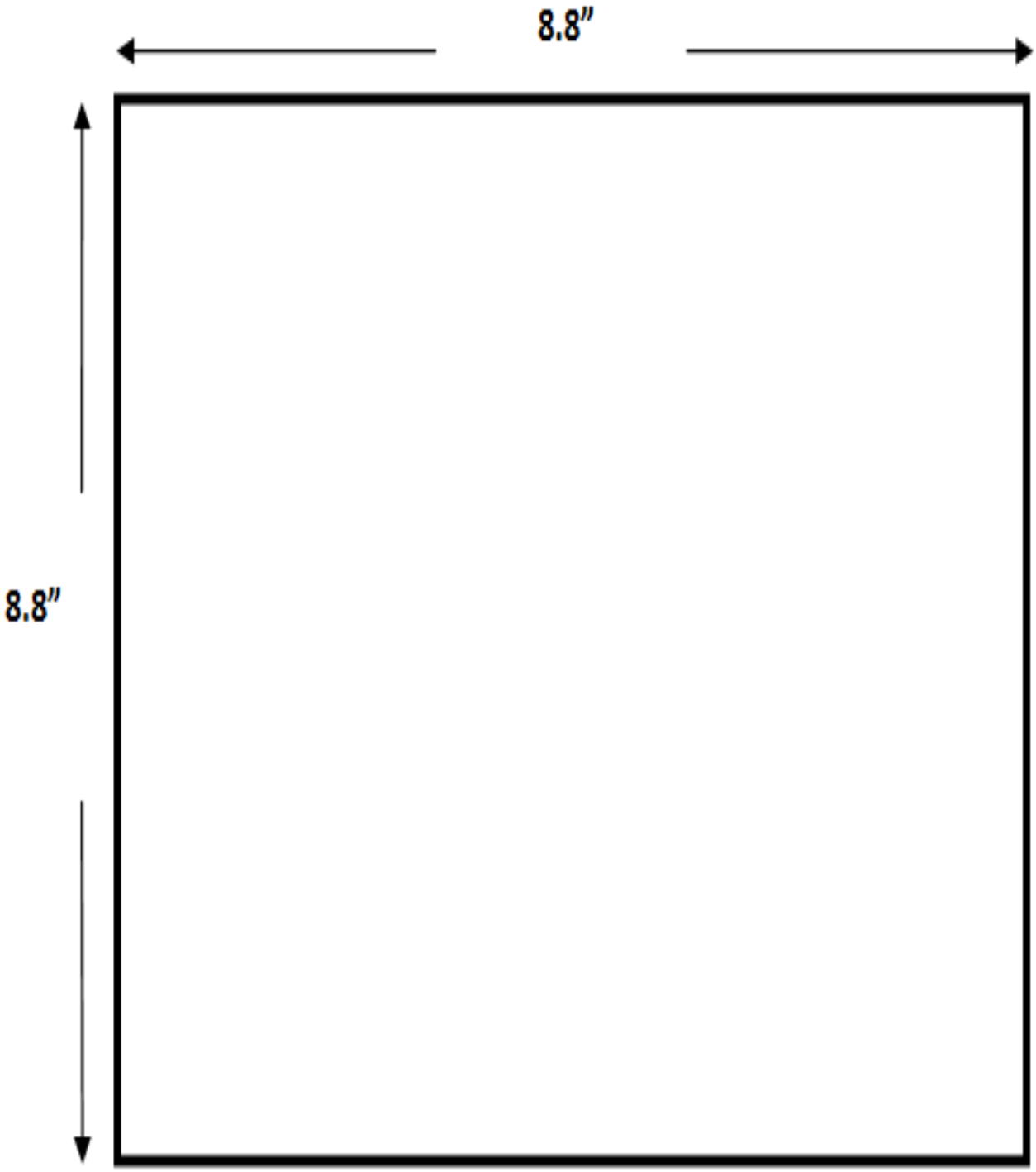


Fig.4.7.5 (b) Base plate 2

4.7.6 THE COMPLETE DESIGN OF THE CNC MACHINE –

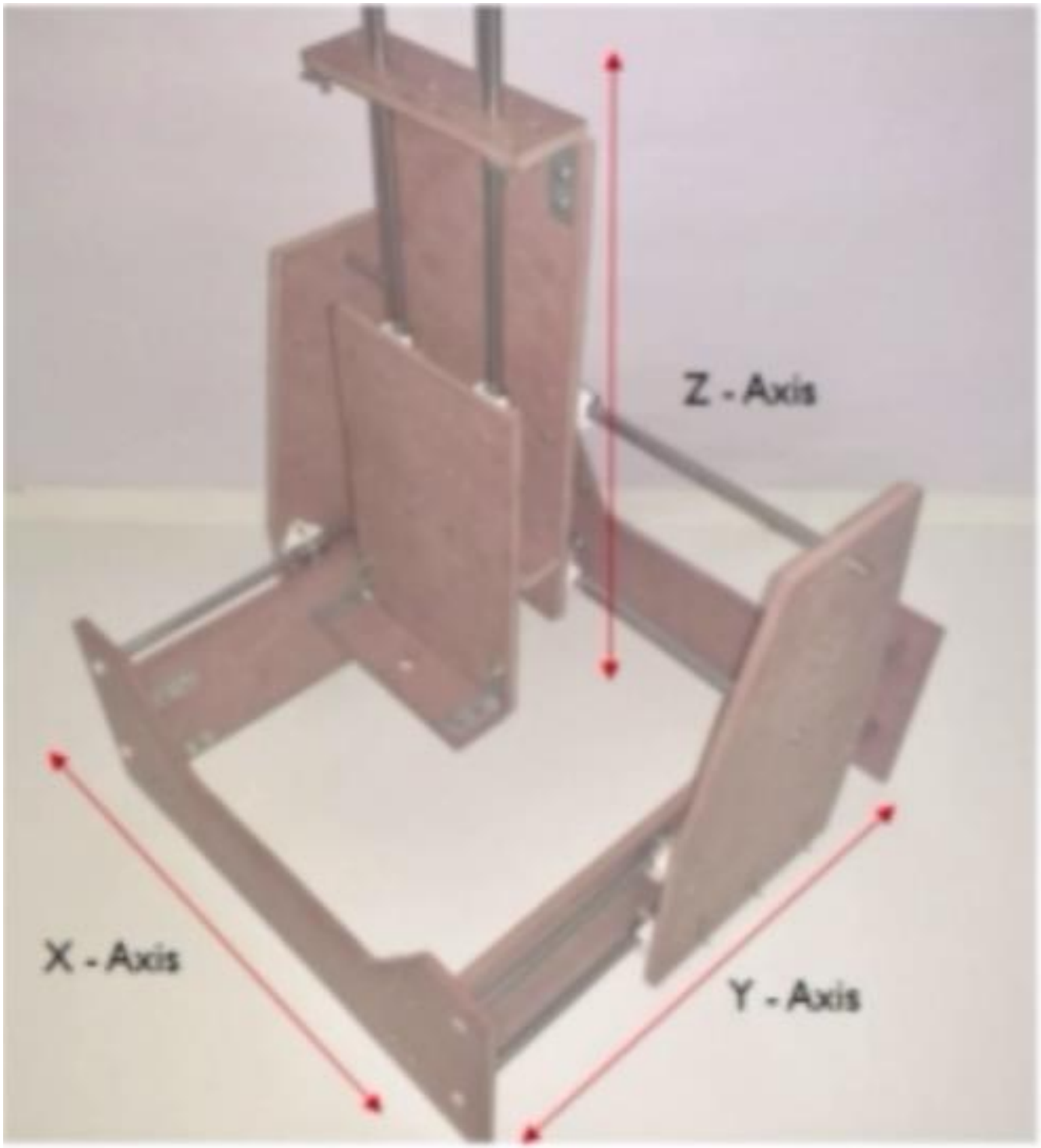


Fig. 4.7.6 Final design of the CNC machine

4.8 CNC MOTION CONTROL :

4.8.1 AXES OF MOTION :

- Degree of freedom
- Translation across three axes
- Rotation about three axes

4.8.2 DIMENSION SYSTEM :

- Incremental : specifies the co-ordinates along 3 axes where the machine tool should move.
- Tool position is defined relative to the previous position of the tool.
- Incremental dimension system has the disadvantage that errors eventually accommodated.
- Thus , absolute routing dimension system is used.
- In which, tool position is defined relative to the fixed axes system.

4.8.3 TOOL MOVEMENT :

- point to point : moves work piece from one point to another.
- Tool moves to a specified point and performs operation at the point.
- Used for the drilling operation.

4.8.4 CONTOURING :

This process provides continuous path while axis moving.

- Tool maintains continuous contact with the part as the tool cuts the contour shape.
- Tool velocity and displacement is controlled.
- Used for machining profiles.

4.8.5 FEED RATE AND SPINDLE SPEED :

FEED RATE : " It is the rate at which tool is advanced in workpiece".

SPINDLE SPEED: "it is the spped of the spindle".

It provides following advantages :

- Best material removal rate
- Maximum tool life
- Good surface finish

4.9 INTRODUCTION TO CNC PROGRAMMING , COMMON CODES :

4.9.1. CNC PROGRAM STRUCTURE :

```
G00 X-25 Y20                    // BLOCK
G91 X-10 Y-10|10 J0 F200 M3     //F200 Is a word and it's a feed rate 200 mm/min
G02 X10 Y1010 J10;
G90 G00 M5 X0 Y0;               // Y is address
G00 X25 Y20
```

- **BLOCK :** "it is a command given to the control unit."
- WORD : "composed of an identification letter and numerals."
- **ADDRESS : "**it is the identification letter at the beginning of each word.**"**\

4.9.2 STANDARD CNC CODES :

- **G CODES –**

"It prepares the microcontroller to prepare specific operation."

- **M CODES –**

"Turn on/ off different functions".

M03	M04	M06	M30
Direction of rotation clockwise	Direction of rotation counterclockwise	Tool change with automatic retraction	End of program return to beginnir the program

Table.1. M codes

- **F,H,D,P,T :**

Represent function : Feed, speed, subroutine call ,tool number etc.

4.9.3 NC INFORMATION :

ONE BLOCK OF INFORMATION

N	G	X	Y	M
SEQ.NO	G PREP.FUNC.	DIMENSION	DIMENSION	MISC.
N001	G01	X12345	Y06789	
				M03

Table. 2. NC information

4.9.4 G – CODES :

SR. NO.	CODE	OPERATION
1.	G90 / G91	ABSOLUTE AND INCREMENTAL DIMENSION
2.	G00	RAPID POSITIONING
3.	G01	LINEAR INTERPOLATION
4.	G02 / G03	CIRCULAR INTERPOLATION
5.	G40 /G41 /G42	CUTTER COMPENSATION

Table.3.G codes

- G90/G91: By using this command we can set the unit for our system whether it can be in mm, inches or cm.
- G00 : This command is used for Rapid positioning. While drilling cycles this command is very useful. we can minimize the time required for overall drilling by using this command of rapid poisoning in this command the tool moves rapidly form one position to another.
- G01: in this command we use linear interpolation. As the tool reaches to the drilling location , it starts rotating clockwise or anticlockwise and this helps to drill hole in the job at desired location.
- G02/G03: This command is used for the circular interpolation.
- G40/G41/G42: This command is used for the cutter compensation.

4.10 FLOWCHART –

4.10.1. Flowchart of the proposed system:

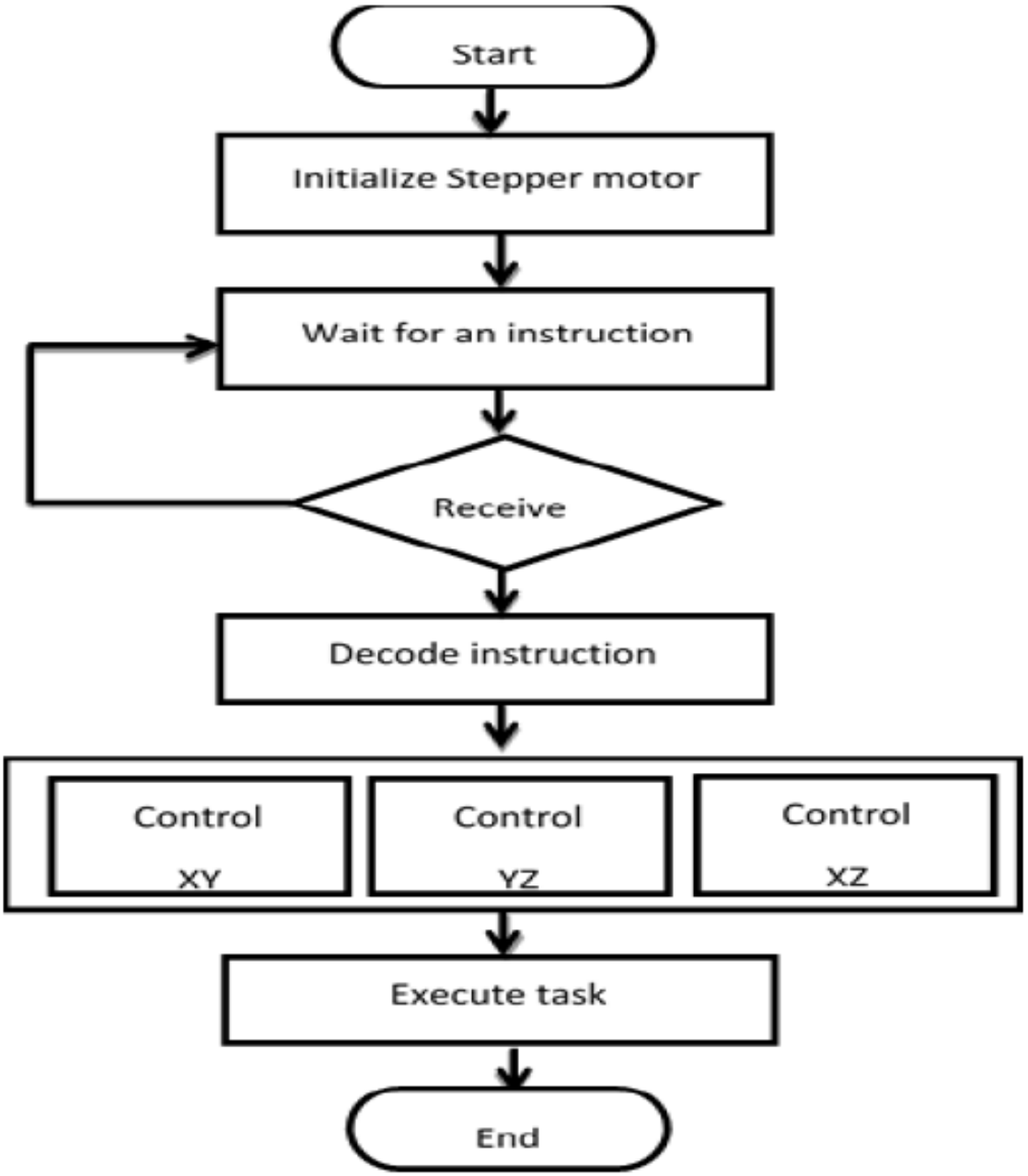


fig.4.10(a)Flowchart of the system

4.10.2. Flowchar t of the software procedure:

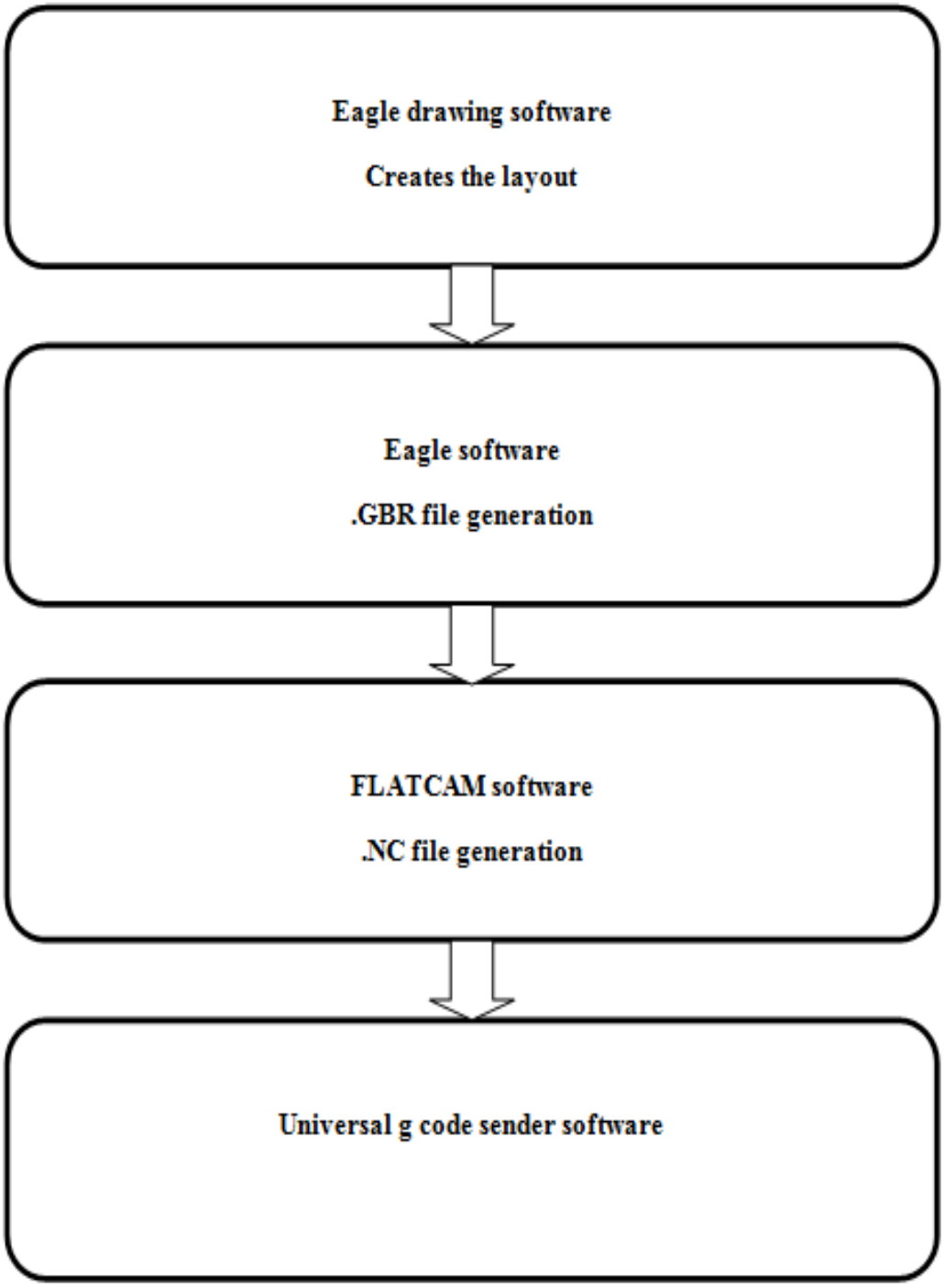


Fig.4.10(b) Software procedur

4.11].HARDWARE DESCRIPTION OF CONTROLLER:

4.11 ATMEGA328 MICROCONTROLLER :

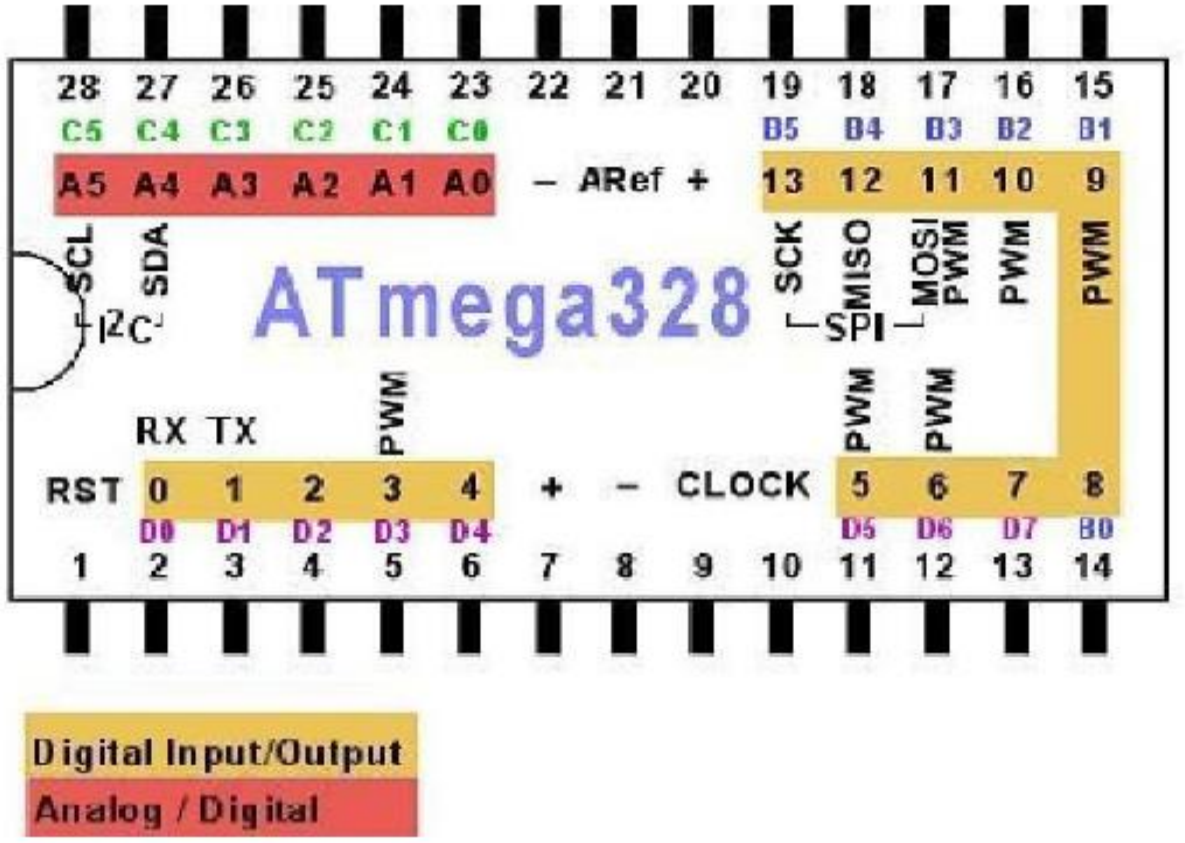


Fig.4.11.a.ATmega328 MICROCONTROLLER

FEATURES

- High performance, low power AVR® 8-bit microcontroller
- Advanced RISC architecture
- 131 powerful instructions – most single clock cycle execution
- 32 8 general purpose working registers
- Fully static operation
- Up to 16MIPS throughput at 16MHz
- On-chip 2-cycle multiplier
- High endurance non-volatile memory segments

- 32K bytes of in-system self-programmable flash program memory
- 1Kbytes EEPROM
- 2Kbytes internal SRAM
- Write/erase cycles: 10,000 flash/100,000 EEPROM
- Optional boot code section with independent lock bits
- In-system programming by on-chip boot program
- True read-while-write operation
- Programming lock for software security
- Peripheral features
- Two 8-bit Timer/Counters with separate prescaler and compare mode
- One 16-bit Timer/Counter with separate prescaler, compare mode, and capturemode
- Real time counter with separate oscillator
- Six PWM channels
- 8-channel 10-bit ADC in TQFP and QFN/MLF package
- Temperature measurement
- Programmable serial USART
- Master/slave SPI serial interface

4.11.1. PIN CONFIGURATIONS :

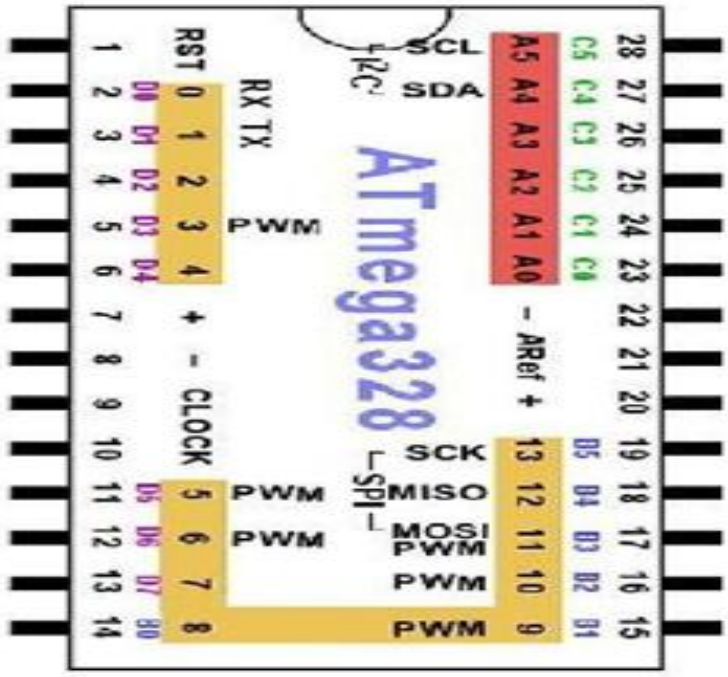


Fig.4.11.b. PINOUT OF ATmega328

4.11.1.PIN DESCRIPTIONS

4.11.2. VCC

- Digital supply voltage.

4.11.3 GND

-Ground

4.11.4 Port B (PB7:0) XTAL1/XTAL2/TOSC1/TOSC2

Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have
symmetrical drive characteristics with both high sink and source capability. As inputs, port B pins that are externally pulledlow will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomesactive, even if the clock is not running.
Depending on the clock selection fuse settings, PB6 can be used as input to the inverting oscillator amplifier and input to theinternal clock operating circuit.Depending on the clock selection fuse settings, PB7 can be used as output from the inverting oscillator amplifier.If the internal calibrated RC oscillator is used as chip clock source, PB7..6 is used as TOSC2..1 input for the asynchronousTimer/Counter2 if the AS2 bit in ASSR is set.

4.11.5 Port C (PC5:0)

Port C is a 7-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The PC5..0 output buffers havesymmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulledlow will source current if the pull-up resistors are activated. The port C pins are tri-stated when a reset condition becomesactive, even if the clock is not running.

4.11.6 PC6/RESET

If the RSTDISBL fuse is programmed, PC6 is used as an input pin. If the RSTDISBL fuse is unprogrammed, PC6 is used asa reset input. A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is notrunning. The minimum pulse length is given in Table 28-4 on page 261. Shorter pulses are not guaranteed to generate areset.

4.11.7 Port D (PD7:0)

Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The port D output buffers havesymmetrical drive characteristics with both high sink and source capability. As inputs, port D pins that are externally pulledlow will source current if the pull-up resistors are activated. The port D pins are tri-stated when a reset condition becomesactive, even if the clock is not running.

4.11.8 AVCC

AVCC is the supply voltage pin for the A/D converter, PC3:0, and ADC7:6. It should be externally connected to VCC, even if
the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter. Note that PC6..4 use digitalsupply voltage, VCC.

4.11..9 AREF

AREF is the analog reference pin for the A/D converter.
ATmega328P [DATASHEET] 5
7810D–AVR–01/15

4.11.10 ADC7:6 (TQFP and QFN/MLF Package Only)

In the TQFP and QFN/MLF package, ADC7:6 serve as analog inputs to the A/D converter. These pins are powered from the
analog supply and serve as 10-bit ADC channels.

ATmega328P is a low-power CMOS 8-bit microcontroller based on the AVR® enhanced RISC architecture. Byexecuting powerful instructions in a single clock cycle, the ATmega328P achieves throughputs approaching 1MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

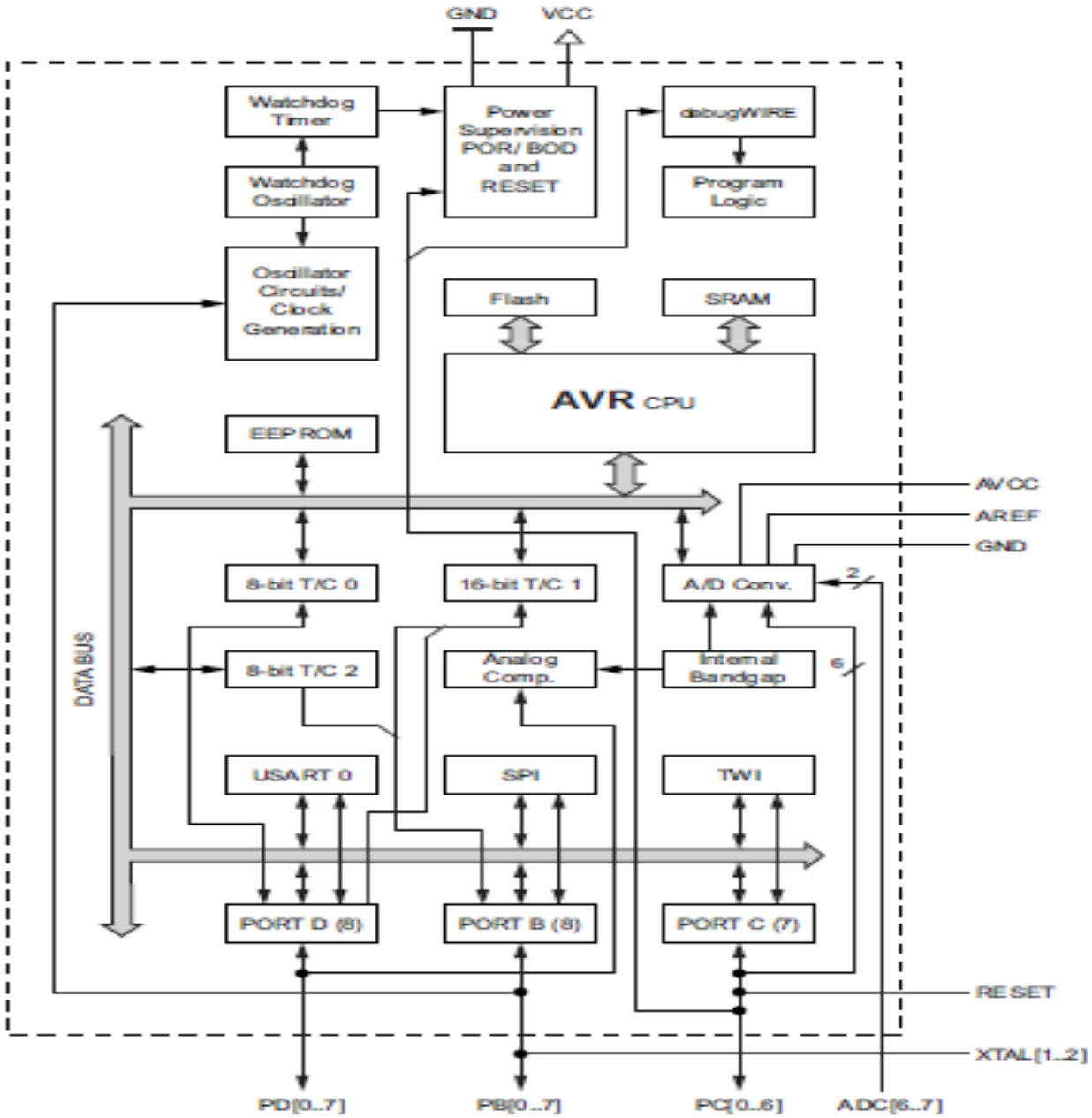


Fig. 4.11.c. Block diagram of ATmega328

The AVR core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directlyconnected to the arithmetic logic unit (ALU), allowing two independent registers to be accessed in one single instructionexecuted in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten timesfaster than conventional CISC microcontrollers.The Atmel® ATmega328P provides the following features: 32K bytes of in-system programmable flash with read-while-writecapabilities, 1K bytes EEPROM, 2K bytes SRAM, 23 general purpose I/O lines, 32 general purpose working registers, threeflexible Timer/Counters with compare modes, internal and external interrupts, a serial programmable USART, a byteoriented2-wire serial interface, an SPI serial port, a 6-channel 10-bit ADC (8 channels in TQFP and QFN/MLF packages), aprogrammable watchdog timer with internal oscillator, and five software selectable power saving modes. The idle modestops the CPU while allowing the SRAM, Timer/Counters, USART, 2-wire serial interface, SPI port, and interrupt system tocontinue functioning. The power-down mode saves the register contents but freezes the oscillator, disabling all other chipfunctions until the next interrupt or hardware reset. In power-save mode, the asynchronous timer continues to run, allowingthe user to maintain a timer base while the rest of the device is sleeping. The ADC noise reduction mode stops the CPU andall I/O modules except asynchronous timer and ADC, to minimize switching noise during ADC conversions. In standbymode, the crystal/resonator oscillator is running while the rest of the device is sleeping. This allows very fast start-upcombined with low power consumption.The device is manufactured using Atmel high density non-volatile memory technology. The on-chip ISP flash allows theprogram memory to be reprogrammed in-system through an SPI serial interface, by a conventional non-volatile memory programmer, or by an on-chip boot program running on the AVR core. The boot program can use any interface to download the application program in the application flash memory. Software in the boot flash section will continue to run while the application flash section is updated, providing true read-while-write operation. By combining an 8-bit RISC CPU within-system self-programmable flash on a monolithic chip, the Atmel ATmega328P is a powerful microcontroller that provides a highly flexible and cost effective solution to many embedded control applications.

5. 1 G Code Example

The program, given below, will draw a 1” diameter circle about the origin.

```
$ AddregPart 1 15,15
/ADDING THE WORKPICE TO THE MILL ABD DEFINING ITS PLACEMENT DISTANCE FROM ORIGIN
/RELOCATE THE ORIGIN TO THE WORKPIECE EDGE
G92 X15 Y15 Z5
/ ADD TOOL
T1 M06
/POSITION TOOL TO THE ORIGIN
G90 G00 X0 Y0 Z5
/WRITE THE PROGRAM
G00 X15 Y15 Z5
G01 X35 Z-3
Y35
Z5
G00 X0 Y0
M30
/TOOL CUTS THE WORKPIECE TO THE DEPTH OF 3mm AND IS BROUGHT BACK TO ORIGIN'
```

5.2 CNC Simulator:

Fig. 5.1 CNC simulator

5.3 Software Status;

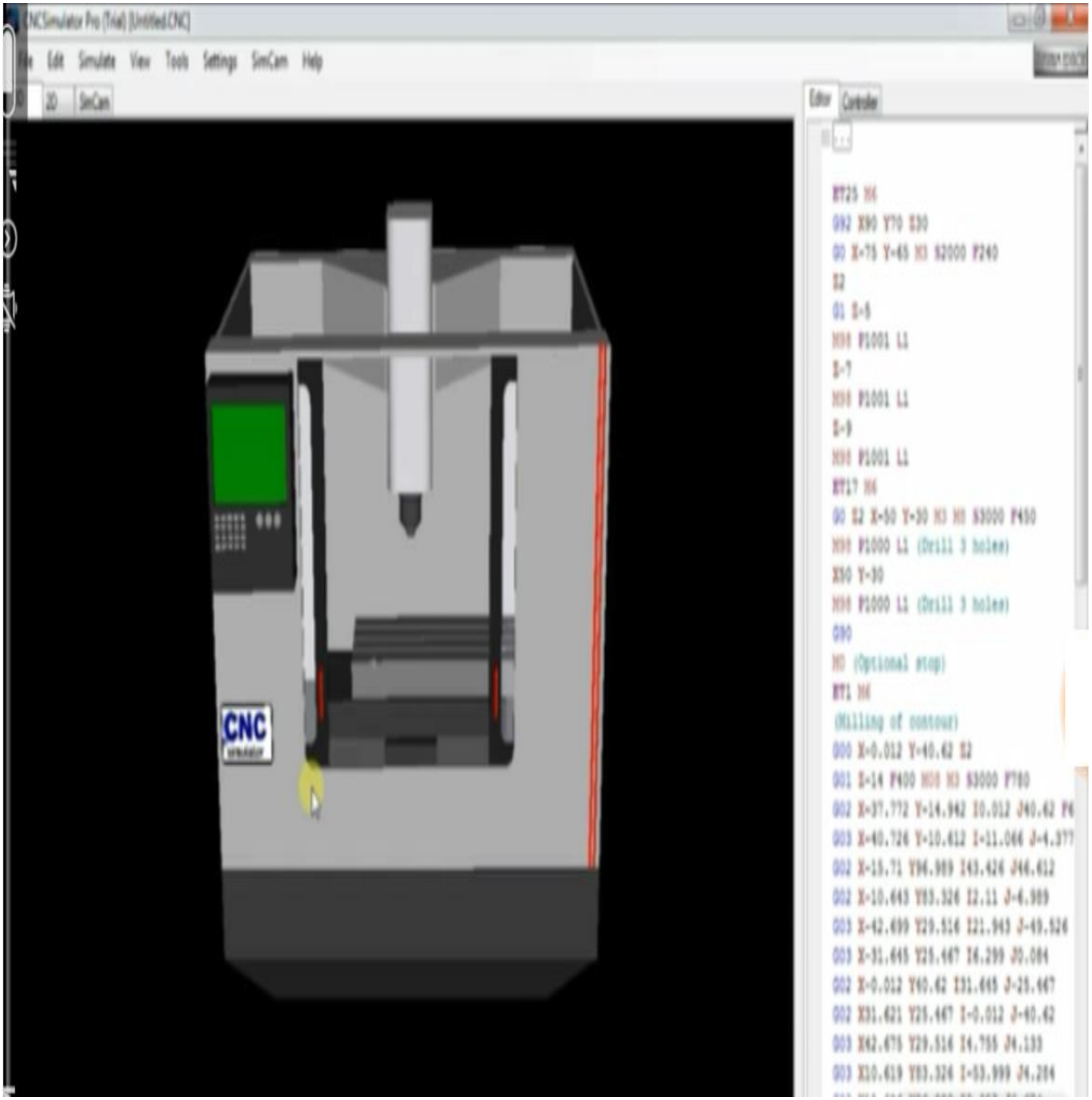
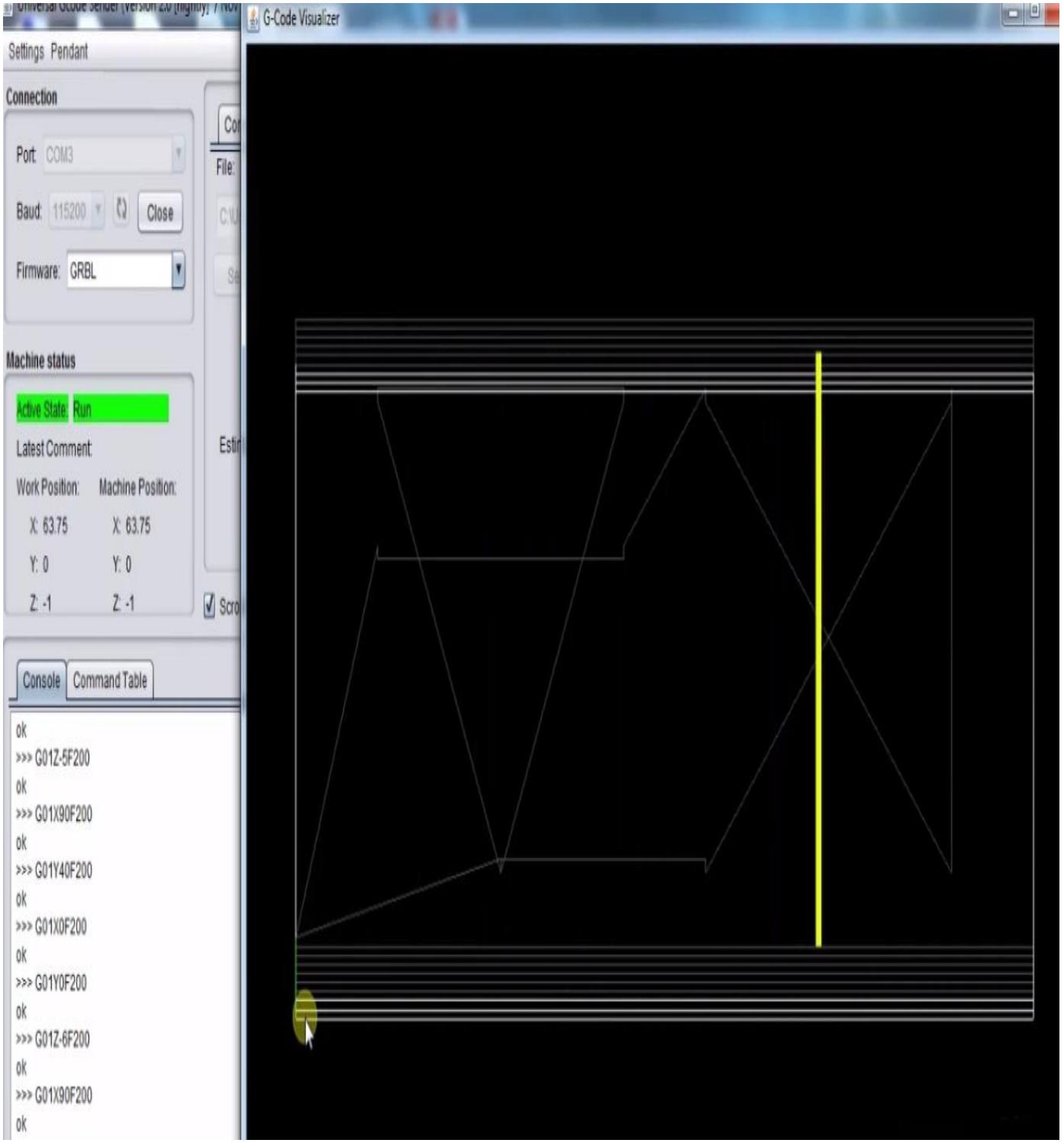


Fig5.2 Software status

5.4 UNIVERSAL G CODE SENDER SOFTEARE:



Fig,5.3 Universal G code Sender Software

ADVANTAGES:

- A very low cost low budget CNC machiene can be built by this method.
- It reduces the human efforts.
- Because of automation the huge amount of task can be done without getting any errors as compared to the traditional drilling system which is operated manually.
- This system is efficient than the traditional drilling method.

DISADVANTAGES:

- Skilled labour is required for handling such machienes.
- Maintenance is required.
- Cost is relatively high compared to traditional drilling machiene.

CONLUSION

Machining is the part of manufacturing metal products and it is the art of removing material from it efficiently and it requires skill and requires energy if manual machining is to be done. In this proposed system , we are using the Arduino UNO for the purpose of automated machining. Arduino UNO controls the complete operations such as drilling, milling and lathing based on the G codes provided. This system is made as efficient as possible by making use of various open source softwares , low cost electronic components including controller and motors and made less complex by making use of the GRBL shield by reducing the wirings. The computer numerical control is used to provide the commands to the machine to perform the operation.

By taking into consideration the main motive of this project to reduce the time consumption and required man power and to increasing the efficiency and production rate and mainly making these machines affordable to the commoners as well as to the hobbyist of making PCBs , we are presenting here the idea of "automatic drilling using CNC and flatCAM".

Using small machine tools to fabricate small scale parts can provide both flexibility and efficiency in manufacturing approaches and reduce capital cost, which is beneficial for small business. ARDUINO based 3 axis drilling machine is designed and implemented under very limited budget.

In this project, we build a machine which has high accuracy and low cost as compared to large CNC machine.

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